U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION, THOMAS F. HUNT, DIRECTOR; CHARLES F. SHAW, IN CHARGE SOIL SURVEY.

SOIL SURVEY OF THE ANAHEIM AREA, CALIFORNIA.

BY

E. C. ECKMANN, IN CHARGE, A. T. STRAHORN, AND L. C. HOLMES, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND J. E. GUERNSEY, OF THE UNIVERSITY OF CALIFORNIA.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1916.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1919

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., April 9, 1918.

SIR: In the extension of the soil survey in the State of California, work was undertaken in the Anaheim area and completed during the field season of 1916. This work was done in cooperation with the University of California Agricultural Experiment Station.

The accompanying report and map cover this survey and are submitted for publication as advance sheets of Field Operations of the Bureau of Soils for 1916, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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SOIL SURVEY OF THE ANAHEIM AREA, CALIFORNIA.

By E. C. ECKMANN, In Charge, A. T. STRAHORN and L. C. HOLMES, of the U. S. Department of Agriculture, and J. E. GUERNSEY, of the University of California.—Area Inspected by MACY H. LAPHAM.

DESCRIPTION OF THE AREA.

The Anaheim area comprises the most important agricultural sections of Orange County, California, and in its northern and northeastern extension small parts of the adjacent counties of Los Angeles and San Bernardino. The area lies southeast of Los Angeles and fronts on the Pacific Ocean for a distance of about 22 miles, extending inland a maximum distance of about 25 miles. Its average width from east to west is about 24 miles and its average length from north to south about 25 miles. On the west it adjoins the Los Angeles area and on the north the Pasadena area, covered by previous soil surveys. It includes the entire area covered by the Santa Ana survey made in 1900[1] and a part of the soil survey of the Los Angeles area completed in 1903,[2] the work of these earlier surveys being revised in the classification and mapping of the soils in the present survey.

FIG. 1.—Sketch map showing location of the Anaheim area, California.

The area is bounded on the east and southeast by a rough and mountainous section, lying mainly within Orange County. This rough section contains relatively small areas of agricultural land. It is bounded on the southwest by the coast line, which is rather regular and has a northwest and southeast direction. The area is irregular in outline, but is bounded by straight lines except along the ocean front. It covers 496 square miles, or 317,440 acres.

The Anaheim area occupies a part of the Coastal Plain division of the Valley of Southern California[3] with some of the adjacent hilly and mountainous country. Physiographically it comprises three rather distinct divisions—hills and mountains on the north and east,

[1] Field Operations of the Division of Soils, 1900.
[2] Field Operations of the Bureau of Soils, 1903.
[3] Water-Supply Paper 219, U. S. Geol. Survey.

remnants of old valleys or marine terraces occurring at the base of the mountains or as isolated areas along the coast, and smoothly sloping plains consisting of alluvial fans and river flood plains. The fans and flood plains constitute the greater part of the area. They slope southwestward to the ocean from the mountains on the northeast.

The northern boundary of the area runs near the crest of the Puente Hills, which extend from a point about 12 miles southeast of Los Angeles in a southeasterly direction for a distance of about 22 miles. The highest peak of this range is San Juan Hill, which has an elevation of 1,780 feet and is just outside the area to the east of its northern extension. These hills occupy a strip in the northeastern part of the area, having a maximum width of about 5 miles and gradually narrowing to the west to less than 1 mile. Their southern base lies at about 400 feet elevation, from which they rise to elevations ranging from 1,000 to 1,600 feet or more. Some of the slopes are rather smooth and are tillable, but most are sufficiently broken to be useful only for pasture. The hill areas support a brushy growth, with trees on the more moderate slopes.

The Puente Hills separate the main part of the Anaheim area from such agricultural areas as the San Gabriel and San Jose Valleys to the north. Their southeastern extension is terminated by the Canyon of the Santa Ana River. This river enters the area about 6 miles south of its northeastern corner, and the lower extensions of the Santa Ana Mountains extend into the area south of the canyon. These mountains roughly parallel the coast line, and several miles east of the area attain elevations of 4,000 or 5,000 feet. The parts included within this survey, although moderately smooth in places, are predominantly rough and broken, with local stony areas. These hilly areas, like the included portions of the Puente Hills, usually are covered with brush but are not heavily forested. The Cleveland National Forest includes a part of the Santa Ana Mountains and approaches the eastern edge of this survey. The San Joaquin Hills, a part of which is included in the southeastern part of the area, reach elevations of about 1,000 feet, and contain areas of both rough broken and tillable land.

There is an elevated upland region in the northern part of the area, extending southward several miles from the base of the Puente Hills. This section includes several groups of hills that rise distinctly from its general level, such as those south of Brea and La Habra, and is dissected by local valleys and considerably modified by erosion. The region is relatively elevated, and is plainly a remnant of a former valley or coastal plain surface now under process of degradation. The eastern part of the survey likewise contains remnants of such former surfaces, and prominent bodies occur also

along the coast. These areas have a less diversified surface than the surrounding mountains and comprise important agricultural soils.

At still lower elevations than those of the old valley filling and coastal plain surfaces just described are the alluvial fans and long alluvial slopes of the Santa Ana and San Gabriel Rivers, Santiago Creek, and minor streams throughout the central part of the survey. These fans and slopes extend toward the ocean with rather smooth surfaces of gradually decreasing gradients, and near the coast they sometimes terminate in marshes. The material making up this smooth, main part of the area has in some cases partly covered some of the older deposits, but the main streams have broad valleys through the older uplands as they approach the coast.

Elevations in the area surveyed vary from sea level in some of the low areas along the coast to over 1,600 feet in the hills in the northern and eastern parts. Olinda is about 500 feet, La Habra 325 feet, Anaheim 162 feet, and Santa Ana 137 feet above sea level. Some of the towns along the beach are near sea level. The old coastal-plain remnants skirting the ocean have a general elevation of about 100 feet. A considerable part of the area is below 100 feet and most of it is below 200 feet in elevation.

The Santa Ana River crosses the area. This is one of the principal drainage outlets in this part of the State. It drains a large region farther inland, but receives little drainage within this survey, except from land immediately along its canyon and from the Santiago Creek basin. The river enters the area in the northeastern part through a narrow, deep canyon. Its general course is southwestward to a point northwest of Newport Beach, where it turns sharply to the southeast, closely paralleling the coast and separated from the ocean only by a narrow sand barrier, and finally discharges into Newport Bay. A number of old, filled channels and continuous sandy ridges indicate that the river has shifted its course widely in the past. The river enters the area at an elevation of 325 feet, and has an average gradient of about 14 feet per mile to the ocean. In the first 12 miles of its course, or to the junction of Santiago Creek, the average fall is over 18 feet per mile, and it has an average fall of about 9 feet per mile in the remainder of its course. The channel is adequate to handle moderate floods, but when the stream reaches its highest stages overflows occur, causing considerable damage. The river has poorly defined banks, and in some instances is confined within unstable levees.

Santiago Creek is the principal tributary of the Santa Ana River in this survey. It enters the area at a point east of El Modena, flows northwestward for about 2 miles, and then southwestward about 7 miles, entering the Santa Ana River northwest of Santa Ana. The banks of this creek are generally well defined. Where

the stream enters the survey it has an elevation of about 500 feet, and where it joins the Santa Ana River the elevation is about 100 feet. It flows through a canyon for a short distance, and has an average fall of about 40 feet per mile.

The San Gabriel River enters the area several miles west of Norwalk and flows in a southerly direction through the extreme western part, emptying into Alamitos Bay. It follows a rather definite channel, and its banks, though not high, are generally stable. Its current is more sluggish in this part of its course than north of the Paso de Bartolo, and in the 10 miles of its course in this area it has an average fall of about 7½ feet per mile. Overflows from this stream are frequent, but mainly local. Coyote Creek drains a small section in the northwestern part of the area, and unites with the San Gabriel drainage west of Los Alamitos.

A large part of the area surveyed is drained by minor streams which gather water along the lower slopes of the alluvial fans and discharge independently into the ocean. A great many streams issue from canyons in the hilly region and flow across the slopes in gradually disappearing channels.

Probably 50 or 60 per cent of the area has good natural drainage, but a section roughly inclosed by a line extending from La Mirada to the west of Anaheim, through Garden Grove and the western part of Santa Ana, south of Tustin, then southward and westward toward Fairview and westward to the coast, has a high water table and retarded drainage. A number of low, poorly drained areas occur along the coast as marshy, shallow bays. Drainage from the area empties into these bays, and they receive tide water except where protected by levees. Owing to the occurrence of a divide about 3 miles south of Irvine, some drainage from the extreme southeastern part of the area reaches the ocean in the vicinity of Laguna. There is an extensive artesian belt in the western and southwestern parts of the area, through the poorly drained section.

Orange County, the principal part of which is included in this survey, was formed in 1889, and had a population, according to the census, of 34,436 in 1910. It is probable that the area covered by this survey had something less than 40,000 inhabitants in 1910. Since that time, however, the population has greatly increased. About 97 per cent of the population is reported as white, most of the remainder being Asiatic. About 62 per cent of the whites are of native parentage, 20.8 per cent native of foreign or mixed parentage, and about 14 per cent is foreign born, mainly Mexicans and Germans. It is estimated that about 60 per cent of the population of Orange County resides in cities or towns, less than one-half being strictly rural. The average density of population for the entire survey is estimated at about 77 per square mile in 1910.

The northeastern half of the area has the more intensive agricultural development and is the more thickly settled.

Santa Ana, the principal town of the area and the county seat of Orange County, had a population of 8,429 in 1910. This is the most important commercial center and shipping point in the area, with two large beet-sugar factories within a short distance. Orange with 2,920, Anaheim with 2,628, and Fullerton with 1,725 inhabitants in 1910 are important towns in the northeastern part of the area. Huntington Beach, located on the coast, had a population of 815 in 1910, and Newport Beach a population of 445. Brea, Seal Beach, Los Alamitos, Olinda, Garden Grove, Placentia, Tustin, La Habra, El Modena, Westminster, Buena Park, Yorba Linda, El Toro, Villa Park, Talbert, Norwalk, Artesia, and Belflower are towns of local importance, the three last named being in Los Angeles County. Huntington Beach, Los Alamitos, and Anaheim each have a beet-sugar factory. Small towns and stations are distributed through all sections of the area.

Transportation facilities are good. Two steam railroads and one electric system operate lines extending into all parts of the survey. The Atchison, Topeka & Santa Fe Railroad operates a main line to San Diego through the central part of the area, which reaches Fullerton, Anaheim, Orange, Santa Ana, Irvine, and El Toro. A branch from Richfields runs to Olinda, and another from Orange through Olive to Richfields. The Southern Pacific Railroad enters the area at Norwalk, and extends through Buena Park and Anaheim to Santa Ana. A branch reaches from Santa Ana to Newport Beach, one from Tustin Junction to Tustin, and another from Anaheim to Los Alamitos. Westminster, Smeltzer, Wintersburg, and Huntington Beach are reached by a branch line extending southward from Stanton. Lines of the Pacific Electric Railroad reach the principal towns and offer exceptional service for passenger traffic. Two main lines of this system traverse the area; one crosses the central part through Artesia, Cypress, Stanton, Garden Grove, and Santa Ana, and the other extends along the coast, through Seal Beach, Huntington Beach, and Newport Beach. A branch connects Santa Ana and Huntington Beach by way of New Delhi and Talbert, and another connects Santa Ana and Orange. All the principal packing houses and sugar factories are connected directly with the railroads by means of spurs. There is very little ocean traffic, although this promises to increase with the improvement of some of the shallow bays along the coast.

A network of excellent roads and boulevards reaches all the principal centers. Many of the roads are of concrete-base construction, and there are many miles of oil-macadam roads. The highways are serviceable throughout the year and are used to a great extent by motor vehicles. Motor stages are in operation in all parts of the

area, often maintaining closely timed schedules, and considerable freight is carried by motor trucks. The telephone is in common use in all the rural districts.

The local towns, together with Los Angeles and other cities in this part of the State, are the chief markets for the perishable products of the area. Sugar beets are marketed at the beet-sugar factories within the area. The hay and grain crops have a more or less wide distribution, depending somewhat upon the production and prices in other parts of the West. The principal specialized crops, such as oranges, lemons, walnuts, and beans, are shipped to all parts of the United States and abroad. Poultry, dairy, and meat products are marketed in southern California or in other parts of the West or are shipped to desert and mountainous regions where agriculture is a minor industry. There are several important producing oil fields in the area.

CLIMATE.

The Anaheim area has two contrasting seasons, a wet, cool winter season and a dry, warm summer season. Nearly all the agricultural sections of the State have similar distinct seasons, although there are wide variations in rainfall and temperature between different localities. The climate of this area is not greatly different from that of the remainder of southern California or the Los Angeles region, except that it is cooler and slightly more humid than in sections farther in the interior.

The table below gives the mean monthly and annual precipitation recorded at several Weather Bureau stations in this region. Santa Ana and Anaheim are in the east-central, and Irvine, in the southeastern part of the survey, a little nearer the mountains on the east and north than the coast.

Mean monthly and annual precipitation at Weather Bureau stations in the region of the Anaheim area.

Month.	Santa Ana.	Anaheim.	Irvine.	Los Angeles.
	Inches.	*Inches.*	*Inches.*	*Inches.*
January	2.31	2.16	2.57	3.03
February	2.46	2.38	2.58	3.00
March	2.49	2.34	2.69	3.05
April	.25	.72	.98	1.02
May	.34	.34	.53	.48
June	.00	.06	.03	.08
July	.00	T.	.00	.01
August	.07	T.	.00	.03
September	.05	.06	.04	.10
October	.69	.49	.51	.75
November	.45	.80	1.13	1.33
December	2.82	2.46	2.27	2.85
Year	10.93	12.04	13.33	15.73

This table indicates that practically all the precipitation occurs during the months of November to April, inclusive, while some of the summer months are entirely without rain. This fact has a great influence on agricultural practices, and necessitates irrigation for practically all fruits and many other crops having their growing season in the summer. The rainfall varies greatly from year to year, some records showing minimum annual precipitation of 4 or 5 inches and maximums of 35 or 40 inches. The mean annual precipitation at Azusa, just north of this area at the base of the San Gabriel Mountains, is reported as 17.86 inches, and at Riverside, northeast of the area, as 10.56 inches, both stations being separated from this survey and the coast by ranges of hills. Hail, snow, and thunder storms are practically unknown.

The temperature of the area is mild and equable. In general, it is higher in the northern and eastern parts, and this has some influence on citrus and other fruits. The coast section is distinctly cooler, at least during the summer months. In the summer the days are warm and the nights cool, but the range between day and night temperatures is not so great as farther inland.

The following table gives the mean monthly and annual temperatures recorded at Santa Ana, Anaheim, and Los Angeles:

Mean monthly and annual temperatures recorded at Santa Ana, Anaheim, and Los Angeles.

Month.	Santa Ana.	Anaheim.	Los Angeles.
	°F.	°F.	°F.
January	54.3	54.1	53.1
February	57.2	56.3	54.1
March	59.3	59.1	55.6
April	64.9	62.9	57.6
May	69.4	67.2	60.5
June	73.8	69.9	64.5
July	76.2	73.0	67.4
August	76.5	74.4	68.6
September	73.8	71.9	66.5
October	68.0	66.8	62.3
November	61.8	60.8	58.4
December	57.2	56.6	55.3
Year	64.6	64.3	60.3

There is considerable variation in frost conditions in different parts of the survey. The lower areas, in general, are more subject to damaging frosts, so that the higher-lying lands bordering the mountains are best suited for tender crops. The frosts occur usually in December and January, and provision is made for smudging in some parts of the area for the protection of citrus fruits.

The days frequently are cloudy and foggy in the rainy season, particularly in the lower parts of the area. Light fogs are common

in late spring and early summer, but rarely remain during the entire day. Damaging winds are rare. The prevailing wind direction is from the southwest. The coast areas are subject to cool ocean breezes, which influence the agriculture of this section, and hot, dry winds arising in the interior desert regions, sometimes locally referred to as "Santa Anas," occasionally occur.

There is a growing season of about 10 months for crops that are very sensitive to frosts, while hardy crops can be grown throughout the year. Grain and grain-hay crops make their principal growth in the winter, or wet season, and this is also true of the native pasture grasses in uncultivated areas and the hilly regions. The pasturage dries up by the middle of the summer, and grazing conditions are most favorable during late spring, except in the poorly drained areas.

In general, the climate of the area is favorable for the production of a wide range of crops. Owing to the moderate summer temperatures, the production of irrigated crops is possible with lighter applications of water than are necessary in many parts of the State.

AGRICULTURE.

The Anaheim area, with the exception of a small section near El Toro and some hill lands in the northern part, was included in old Spanish land grants. These grants originally were utilized for an extensive form of agriculture, being devoted chiefly to grazing and to some extent to grain growing. Inextensive plantings of fruits and vegetables were made to supply the home demand. About 1860 the development of a more intensive system of farming began. Extensive farming gradually declined, and a high state of agricultural development has been attained. Between 1860 and 1890 considerable progress was made in the development of an important fruit and grape industry. Irrigation developed rapidly during this period. Between 1890 and 1900 further important development took place through the drainage of the lower lands of the area. Drainage proceeded rather slowly at first, but it was soon demonstrated that the lands of the "swamp country" which had been considered practically valueless could, by drainage, be made very profitable as truck soils, celery being the main crop. Drainage has been established over a large part of the low-lying area, and the land is used for intensive crops. About 1890 the grape industry, which was then one of the most important in the area, was practically wiped out by diseases, and it has not been reestablished. The celery industry also has declined until it is of little importance.

At the present time parts of the area are very intensively farmed. Many crops are remarkably localized, and are largely grown for sale and exportation rather than for home consumption. The principal

crops may be classed in three general groups. The most important group comprises the irrigated orchard products, mainly oranges, lemons, and walnuts, with some deciduous fruits. Second in importance is the group of cultivated field crops, of which sugar beets and beans receive by far the most attention. These crops are grown in many cases without irrigation. The third group includes grain and grain hay, the general tendency of agricultural development being to restrict the area devoted to these crops. There are in addition many other crops of less importance, such as truck crops and alfalfa. Dairying, poultry raising, apiculture, and stock raising are important but subsidiary industries.

The east-central part of the area is the center of one of the most intensively developed orchard districts of the State. Nearly the entire section from the vicinity of Fullerton southeastward almost to Irvine is a region of small land holdings and producing orchards. The section extends oceanward from the foothills on the east to about the 100-foot contour, although its lower limits are not sharply defined. It yields by far the greater part of the orchard products of the area. Another intensive district lies around La Habra along the foothills in the northern part of the survey. (Pl. I, fig. 1.) The general tendency in this section is to have the lemon plantings confined to the positions least affected by frost, in most instances nearest the mountains. Oranges occupy a somewhat lower average position, while English walnuts are prominent in the lowest areas. Other intensive but smaller orchard districts are located at Newport Heights and around El Toro and La Mirada.

The western and southern parts of the survey contain extensive acreages of sugar beets and lima beans. The southeastern part of the area in particular includes many square miles of continuous bean fields, while the southwestern part has similar areas of sugar beets, broken by small acreages of grain and grain hay. Grain and grain-hay crops are grown extensively in the northern part of the area, and in general wherever the more profitable crops are impossible. The general tendency is toward intensive farming, in which the development of irrigation for the elevated soils and drainage of the lowlands are the most important factors.

Citrus fruits are very important in both acreage and value. According to figures published by the California State Commission of Horticulture,[1] there were in 1915, 3,000 acres of bearing and 1,550 acres of nonbearing lemon and 9,806 acres of bearing and 6,500 acres of nonbearing orange trees in Orange County, nearly all of these being included in this survey. There are in addition several hundred acres of citrus fruits in that part of the survey lying in Los Angeles County. A large percentage of the oranges, especially of the younger plant-

[1] Monthly Bulletin, State Commissioner of Horticulture, March, 1916.

ings, are Valencias, there being only about 900 acres of Navels and practically no seedlings. Orange County, according to the census of 1910, produced 1,247,905 boxes of oranges and 74,227 boxes of lemons in 1909. The lemons in the area are chiefly young trees and the production is increasing. Grapefruit is grown to a small extent. Citrus fruits are very profitable in the localities suited to their production. The bulk of the fruit is marketed through efficient cooperative organizations; though there are several independent packing houses that handle a part of the crop.

The production of English walnuts is very profitable, and Orange County is the leading county in the State in this industry. The climate of parts of the area is particularly suited to walnut growing. There are about 12,000 acres of bearing and 1,900 acres of nonbearing walnut trees in Orange County, with several hundred acres in the included part of Los Angeles County. The walnut grown is of high quality. It commands a good price, and the demand seems to be increasing. Many of the orchards are heavy producers and yield large revenues. In many cases the orchards are subject to injury by blight. The crop is marketed largely through a cooperative association.

There are about 1,600 acres of apricots in Orange County, and practically all the trees are in bearing. Growers have been somewhat discouraged in recent years by a number of crop failures and the prevalence of rust. Wet weather at the time of setting of the fruit is very injurious to the crop, and in this respect the area is at a disadvantage as compared with the drier interior valleys. Some orchards have recently been discontinued, and on the higher lands citrus fruits have been substituted.

There are about 385 acres of olives in Orange County and extensive plantings in the included part of Los Angeles County. The plantings are mainly included in several large orchards. Olives usually receive little care and produce irregularly. More extensive plantings were made at one time, but were found unprofitable. It is believed that the climate of the area is not well suited to olive production.

Small plantings of apples have recently been made. The Bellflower, Winter Paradise, Winter Banana, and Pearmain are the principal varieties. Numerous other fruits are grown in a small way, including avocados, loquats, peaches, plums, prunes, pears, and figs. Avocados (commonly known as alligator pears) are a recent introduction. Some trees have proven highly profitable, and considerable interest is being taken in the crop. This is a tropical fruit, and is similar to or even more sensitive than citrus fruits in its climatic requirements. A few loquats are grown commercially. The climate is well adapted to this fruit and the trees bear heavily, but

the product is not well known and the market is limited. New and better varieties are being developed; and as the fruit is suitable for use fresh and in making jellies and jams, the crop may increase in importance. Plums and prunes have declined in importance.

On the lower lands, after the decline of celery production, sugar beets became the main crop. Five beet-sugar factories in the county handle the product. The prevailing price for beets in 1916 was $4.50 per ton for 15 per cent sugar, with 30 cents per ton added for each additional per cent. The average yield for Orange County is 8½ tons per acre, but the better land yields 15 tons or more. The average sugar content is high.

Beans constitute another important crop. The lima varieties are the most important, the yield of these for 1910 in Orange County being reported as 150,000 sacks. Blackeyes are also extensively grown, about 10,000 acres being reported in 1916. The average yield of beans is about 12 sacks, of 78 pounds each, per acre.

Grain and grain hay are important and extensive crops, some areas being cut entirely for hay, while others are used for either grain or hay, depending somewhat upon the season. (Pl. I, fig. 2.) In the 1910 census, cereal crops, of which barley constitutes more than 80 per cent, are reported on 32,415 acres in Orange County, with a production of 808,381 bushels. This includes nearly 11,000 bushels of wheat and about 31,000 bushels of oats. Grain was cut green for hay on 35,753 acres, with a reported yield of 53,045 tons.

A number of other crops are grown in a smaller way, and some of these are highly profitable. Celery was a very important and valuable crop on the lowlands about 15 years ago, but owing to blight and other factors the crop has been reduced to a place of little importance. Orange County was at one time a very important grape-producing county. About 1890, however, the so-called "Anaheim vine disease" appeared and devastated the entire vineyard area. This so-called disease still baffles investigators, although it has been under observation for many years. Grapes are now grown only in small quantities within the area surveyed.

Truck crops and small fruits are grown in the northwestern part of the area for the Los Angeles market. The industry has not developed greatly owing to competition of market gardeners in the region directly south of Los Angeles. Some truck crops are grown as intertilled crops in young orchards, cabbage commonly being grown in this manner. A few sweet potatoes are grown on the light-textured soils.

Grazing of range cattle, at one time the most important industry of the area, is now limited to the rougher hilly regions and to the lower, more poorly drained sections. Dairying is practiced in the rough or poorly drained areas but is of little importance as com-

pared with other industries. In the 1910 census the dairy products for Orange County, excluding those for home use, are valued at $290,247. There are several dairies also in the part of Los Angeles County within this survey. There is considerable land suitable for alfalfa in the area, but it is largely used for more profitable crops, and the acreage in alfalfa is small, being reported in the 1910 census as 5,304 acres. Beet pulp is an important feed for dairy and other stock.

Citrus crops, particularly lemons, are highly susceptible to frost, and unless the locations are well chosen the grower is likely to suffer considerable loss through this cause. Orchard heating is practiced locally on cold nights. The orchards commonly are given good care. While the trees are young the land is often intercropped, but the mature orchards are given clean cultivation or planted to some legume or other green-manuring crop. The worst pest of the citrus fruits is scale, the control of which demands a large expenditure for fumigation. Irrigation is required for citrus fruits, and several applications of water usually are given during the season.

The older walnut groves are seedlings, but recent plantings are being made on black-walnut rootstock. In many of the orchards the trees are 40 feet apart, but in the younger orchards a spacing of 50 or 60 feet is practiced. Young orchards are generally either interplanted with fruit trees which are removed as the walnuts mature, or are intercropped with alfalfa, beans, or other crops. The mature orchards may or may not be irrigated, and usually are clean cultivated. Walnuts are handled mainly by the packing houses of a growers' association.

Sugar beets are planted from late in December until early in May. Early planting utilizes more of the soil moisture. About four or five weeks after planting they are thinned by hand and the land is rolled. The beets usually are cultivated once before thinning and several times afterwards and are hoed once or twice. The beets grown on lighter or drier soils are often irrigated, generally twice, between the middle of May and the last of June. They are harvested from the last of July until the last of November.

Beans are chiefly grown without irrigation, the greater part of the acreage in the area being comprised in a single holding known as the San Joaquin ranch. Some beans are interplanted in young orchards, and the crop is sometimes grown on the better-drained lowlands in rotation with beets. The most important process in bean culture is the preparation of the soil before seeding. The land is plowed in the fall, and after receiving the winter rains is cultivated several times to conserve moisture and remove weeds. The crop usually is planted early in May, after the last rains, in rows from 30 to 36 inches or more apart. Several shallow cultivations are

given the young crop. The beans ripen between the latter part of August and the latter part of September and are harvested with special horse-drawn cutters which cut the vines at or just below the surface. They are then stacked by hand and, after drying, are thrashed from the stack.

Citrus fruits are confined to those parts of the area that are relatively frost free, well drained, and capable of being irrigated. Such conditions prevail along the hills to the north and east. Some recent plantings are being extended farther out on the plain and on the benches along the ocean. Some of the more exposed plantings require special precautions against frost. Citrus friuts are grown and do well on a variety of soils, but the best orchards are on soils of considerable depth and of medium texture, with permeable subsoils. Some of the recent plantings, however, are on soils of light texture with loose, gravelly subsoils. Extensive plantings have also been made recently on soils underlain at shallow depth by relatively impervious, compact clay subsoils, and these seem much less desirable than the deeper soils. Some of the older orchards are on soils of similar nature but with less compact subsoils.

Walnuts are grown largely on the lower lands, where deep, well-drained soil, free from alkali, prevails. (Pl. II, fig. 1.) The walnut tree is very deep rooted and susceptible to adverse subsoil conditions and alkali. Some of the more recent plantings have been made on soils that do not seem well adapted to the crop.

Sugar beets do best on medium to heavy textured soils with a good supply of water. Very light soils often give a relatively low yield of beets, although the sugar content is high. The beet is very resistant to alkali, and for this reason is grown on the alkali-affected soils of the lower poorly drained flats, almost to the exclusion of other crops. (Pl. II, fig. 2.)

Beans are grown on a wide range of soils, but are not grown on soils containing alkali. As they are almost exclusively dry farmed, a soil that absorbs and retains moisture is desirable. On the lower moist lands beans produce a heavy growth of vine, at the expense of seed. Light-textured soils generally mature the crop earlier than heavy soils, and in seasons of early fall rains early maturity is a decided advantage. The yield on the light soils is not ordinarily so large as on the heavier soils. The climate of the area is well adapted to bean culture.

The majority of the farmers of the area are supplied with the most up-to-date machinery and farm equipment. This is especially true of the citrus and walnut growers. Some of the farms of the lower lands are not so well equipped. The present tendency toward the subdivision of property into very small holdings has resulted

in some settlers attempting farming with insufficient capital, and in such cases the farms are not well supplied with machinery.

Crop rotation is not extensively practiced. Beans are grown on the same land year after year without decreased yields. In fact for several years after beans are introduced on new land the yields show slight to material increases. Grain yields are increased by rotation with beans, but where beans can be grown profitably they usually are produced year after year. Although sugar beets have not been rotated in the past it is becoming apparent that yields can be increased by rotation and the practice is growing. Beans, alfalfa, and grain are used for this purpose. The indications are that where possible the growing of beans one year in three makes a good rotation for beets.

The 1910 census reports a total expenditure of $71,118 for fertilizer in Orange County in 1909. Fertilizers are used by the orchardists in considerable quantities, some using commercial mixtures and others barnyard manure exclusively. The latter practice is followed on some of the best-paying orchards in the area.

In the orchards and on the small farms of varied crops the labor is largely performed by the owners. Sugar beets are generally hoed and thinned by Mexican laborers. In the citrus and walnut orchards the labor is performed by the owners with the help of American laborers chiefly, although some Mexicans and Japanese are employed.

The average size of farms is steadily growing smaller. Recently many tracts have been subdivided into farms of 10 acres, 5 acres, and less. Many walnut and orange orchards consist of 10 to 20 acres. The San Joaquin, or Irvine, ranch of 96,000 acres is largely included in this survey. The better agricultural sections of this ranch are farmed in tracts of 160 or 320 acres by tenants and other parts by tenants in larger tracts. Sugar beets are grown on farms of varying size. The 1910 census gives the average size of farms in Orange County as 117.4 acres. According to the 1910 census, 80 per cent of the farms of the county were operated by owners, 16 per cent by tenants, and 4 per cent by managers. The fruit and walnut orchards are almost entirely operated by owners. The San Joaquin ranch is mainly farmed by tenants on a share basis. All leases on the ranch are for one year, with the exception of small areas which are used for orcharding. About one-half the beets in the area are grown by owners and the remainder on a crop-rent basis.

The value of land varies greatly, depending on the crop to which it is adapted and other factors. Some of the land may be considered as semisuburban property, and is held at higher prices than its agricultural use would warrant. Much of the land along the coast is held at high prices, as possible resort property. Sugar-beet land is held

for as much as $500 an acre, which is more than its producing capacity for beets warrants. Land that is being subdivided into small tracts for general or specialized farming is sold at $250 an acre upward. The best citrus land is rated at very high values for the raw land, and bearing groves in good condition often bring as high as $2,000 or more an acre. Walnut orchards in bearing are held at about $1,000 an acre, raw land adapted to walnuts ranging in value from $400 to $500 or more an acre.

SOILS.

The soils of the Anaheim area are mainly identified with three kinds of soil-forming material, or soil provinces, and are included in three general groups: (1) The residual soils, or those derived in place through the weathering and disintegration of consolidated rocks; (2) the old valley filling or coastal plain soils, consisting of weathered and otherwise modified material of old, unconsolidated, water-laid character; and (3) the recent alluvial soils, or those identified as comparatively recent alluvial products without important changes by weathering or internal modification subsequent to deposition. There is a fourth group, including miscellaneous material that are mainly nonagricultural.

By far the greater part of the soils of the State belong in these three main groups. The residual group usually predominates throughout the mountainous regions, the old valley filling or coastal plain group being prominent along valley margins or as terraces along the coast, while the recent alluvial soils predominate on the floors of most of the valleys. The present survey is composed largely of rather uniform slopes or recent alluvial fans laid down by numerous streams, and most of the soils of this area belong to the recent alluvial group.

The three main groups of soils are, for purposes of soil classification, subdivided into groups known as "soil series." A soil series consists of closely related soils having similarities of color, origin, subsoil conditions, and other features which serve to establish their relationship and at the same time to differentiate them from other soil series of the same province. The soil series is further subdivided into soil types, this separation being made on the basis of texture, or the relative quantities of sand, silt, and clay present. Soil types are sometimes further divided into "phases," the phase difference being based on such features as minor color variations, gravel content, depth, or topography. In this manner the soils of the Anaheim area are classed with 9 series, represented by 28 types, 4 of the types having phases, and in addition 5 types of miscellaneous material, 1 of which, Muck and Peat, consists of cumulose soils.

Residual soils.—The residual soils are confined in this survey to the hilly sections along the northern, eastern, and southeastern margins. They are derived principally from sedimentary rocks, largely calcareous shales and sandstones, except in some small areas in the eastern part of the survey. The soils are classed with two series, the Altamont and Diablo, of which the Altamont soils are the more extensive. The two series are similar in origin but differ in some other respects, mainly in color.

The soils of the Altamont series typically are derived from sandstones, shales, and other sedimentary rocks. They are brown in color, but range from light brown to dark brown. The subsoils usually are lighter in color than the surface soils, ranging from light brown to reddish brown, and are often heavier in texture, this difference being less marked in the heavier types. Bedrock usually is encountered at less than 6 feet from the surface. The soils are on the average lower in lime and organic matter than those of the Diablo series, but both soils and subsoils often carry seams or concentrations of lime. They have the rolling, hilly, or mountainous topography typical of the upland, and include shallow and eroded areas with rock outcrop. They are well drained and retentive of moisture. As mapped the series includes small bodies of undifferentiated brown soil derived from basic igneous rocks which if more extensive would be recognized as types belonging to the Olympic series. The series is represented by five types.

The Diablo soils typically are derived from sedimentary rocks quite similar to those giving rise to the Altamont series. The soils are dark gray to black, and the subsoils are lighter colored, with shades of gray or brown, although the black surface soil sometimes rests directly on the parent rock. The subsoil of the lighter textured types is often more compact and heavier textured than the surface material. Bedrock usually is found at a depth of less than 6 feet and commonly is calcareous. The soils apparently are high in organic matter, and the subsoil at least is usually calcareous. The surface is rolling or hilly, and the drainage good. The series is represented by one inextensive type, the clay adobe.

Old valley filling or coastal plain soils.—The soils of the old valley filling or coastal plain province are broadly represented in many parts of the State, practically every valley or basin containing some bodies of this group. The soils are derived from weathered and otherwise modified, relatively old unconsolidated water-laid material. The parent material was derived from a wide range of rocks and subsequent alterations have produced soils which vary widely in color, chemical composition, and in character of the subsoil and substratum. These differences result in the differentiation of a large number of soil series which collectively differ from both the residual soils and

recent alluvial soils. Perhaps the most constant feature of the old valley filling or coastal plain series is their normal occurrence at elevations intermediate between the higher lying residual soils and the lower lying recent alluvial soils, although there are exceptions to this condition. The soils have usually been weathered and modified sufficiently to have produced consistent differences between the soil and subsoil, wherein the latter often has a heavier texture and a more compact and adobelike structure. In some series distinct hardpans are present, while in others the subsoil differs from the surface material only in color and structure. Certain of the series have distinct gravel substrata, and others are distinguished by the calcareous nature of both the subsoil and substratum. The old valley filling soils usually occur as elevated remnants of water-laid deposits, originally either alluvial fans, former valley surfaces, or marine terraces. The surface is more or less eroded, being more diversified than that of the recent alluvial soils but less so than that of the residual soils.

The old valley filling or coastal plain soils province is extensively represented in the Anaheim area by the Ramona, Montezuma, and Antioch series, of which the former occupies by far the greatest acreage. The soils of this province occupy two positions in the area, the first and most extensive being the elevated and usually rolling remnants of former valley surfaces about its northern and eastern margins, and the second the elevated, rather even-surfaced benches along the coast, representing old marine terraces or the lower extensions of old, flattened alluvial fans. Depressed strips of recent alluvial soil or overwashed recent alluvial fans are common, and the northern and eastern bodies give way on the side next the ocean to broad alluvial fans, rather sharp boundaries being the rule. The coast bodies front on the ocean with distinct bluffs of 20 to 200 feet or more, and merge toward the interior with the soils of the recent alluvial fans.

The Ramona soils typically are brown, but range to slightly reddish brown or grayish brown. They are underlain by distinct, heavier-textured subsoils, which in places are compact and of a redder brown than the surface material. The subsoil is not usually distinctly calcareous, though it may contain small quantities of lime. The series is derived from weathered and otherwise modified, old water-laid deposits, the material of which seems originally to have been derived largely from granitic rocks. Some areas in the northern and eastern parts of the area have been derived from sedimentary rocks. The surface usually is slightly uneven or rolling, with local tendencies toward a hog-wallow topography. Drainage usually is good except in the rainy season, when the heavy subsoils retard percolation. Six types of the Ramona series are mapped.

The soils of the Montezuma series typically are dark gray to black, with minor included areas of a brownish tint. The lighter textured

types are friable and retentive of moisture, while the heavier types are often sticky when wet and readily puddled, baking, cracking, and developing a typical adobe structure when dry. The soils usually are high in lime and organic matter. The subsoils are lighter colored than the surface material, and sometimes mottled, commonly with gray, yellow, or brown. The subsoils usually are calcareous, and lime often occurs in nodules, seams, or intermittent layers, sometimes slightly indurated, yet not a hardpan. The surface is rolling, hilly, or locally smooth. The soils typically are derived as weathered or otherwise modified products of old, unconsolidated, water-laid deposits. Drainage usually is good. The Montezuma series is relatively inextensive in this survey. It is represented by two types. In some places they are difficult to separate from the recent alluvial soils of the Dublin series.

The soils of the Antioch series are weathered and otherwise modified, old, unconsolidated water-laid deposits, which seem to have originally been derived largely from sedimentary rocks, but which include material from a wide variety of rocks. They are brown in color, ranging from light brown to dark brown. The subsoils are typically heavier in texture and more compact than the surface soils, although this is less marked in the heavier than in the lighter textured types. The subsoils are lighter colored than the surface soils, being a lighter brown, or more yellowish brown, or in some places grayish. Moderate quantities of organic matter are present in the soils. The subsoils contain concentrations of lime. The country occupied by these soils is slightly uneven or rolling, some areas being hummocky. Drainage usually is good, except for some areas on which water stands during the rainy season. The Antioch series is represented in the Anaheim area by one type. This type is inextensive and variable and not typical in color, being darker than is usual.

Recent alluvial soils.—The soils of this province are important in most of the valleys of the State, and are the ones upon which the greater part of its intensive agricultural products are grown. They consist of recent or comparatively recent deposits made by streams at or near their present levels. The orginal water-laid surface usually is intact except for local drifting by winds or artificial modification. Hog wallows, hummocks, or other topographic evidences of age are rare. The topography is rather smooth. The soils occur in several positions, as over the floors and sloping sides of valleys made up of compound or coalescing alluvial fans, along stream bottoms, or on the lower comparatively recent stream terraces. They are in contrast with the soils of the other provinces not only in surface configuration but also in cross section. Where not of uniform texture and structure to depths of 6 feet or more the soil column exhibits irregular variations without consistent tendencies toward heavier

or modified subsoils, or hardpan. The subsoils are often identical with the surface soil in general character, but contain strata of material of varying texture. The recent alluvial soils are derived as alluvial wash from a great variety of rocks and they vary widely in color and other features. They are deep, friable, and usually permeable, and free from unfavorable subsurface features, such as bedrock or hardpan.

The recent alluvial soils form the most extensive groups in the Anaheim area, covering the entire central part of the survey, with minor valleys and local fans extending back from this main development into the other two soil provinces. Four series of recent alluvial soils are mapped, the Hanford, Yolo, Dublin, and Chino, the Dublin series being relatively inextensive. These soil series are not sharply differentiated in color, origin, or other features, but the average or typical occurrence is sufficiently different to warrant separation.

The Hanford soils are derived predominantly as wash from upland or mountainous areas occupied largely by granitic rocks. They are brown, but have many color variations, with the lighter brown shades predominating. They are typically friable, micaceous, and permeable. The soil material may extend to a depth of 6 feet without change or may be underlain at almost any depth by strata of variable texture. The subsoil usually is slightly lighter colored than the surface material, but may be similar to it. The entire soil section typically is free from compact layers or hardpan, and as a rule there are no apparent concentrations of lime. The organic-matter content is often rather low. The soils occur as alluvial stream bottoms, alluvial fans, and recent stream terraces. Drainage usually is good except in areas subject to a high water table or intermittent overflow. The Hanford series is the most extensive and important in the area. It is represented by four types. These soils average lighter or more grayish brown than in many other parts of the State, and in places approach the color of the Tujunga series. Some of the Hanford soils resemble the related Chino series of darker-colored soils where in contact with them or in local, poorly drained positions. In such localities the subsoils and occasionally the soils are calcareous.

The Yolo soils are derived mainly as wash from upland regions occupied largely by sedimentary rocks and their derivative soils. They are typically nonmicaceous, brown soils, with light-brown or grayish-brown shades predominating. The subsoils usually are lighter colored than the soils, ranging from brown to yellowish brown or light brown. They may be similar to the surface soils in texture, or consist of strata of varying textures. The material usually is friable and retentive of moisture. Moderate quantities of organic matter are present. Concentrations of lime sometimes occur.

The Yolo soils occupy alluvial fans, stream bottoms, or recent stream terraces. The surface usually is gently sloping, and drainage good, except in areas subject to overflow. Parts of some areas having a high water table are affected with alkali. The Yolo series is one of the most important of the area. It is represented by four types which comprise some of the most valuable agricultural sections of the survey. The soils as mapped vary in some cases from the typical. In places they are micaceous and are not distinct in origin from the Hanford series. In other places they are dark colored and resemble the Dublin soils, while other areas are relatively old, with modified subsoils, and approach the Ramona series of the old valley filling soils.

The soils of the Dublin series typically are derived largely as alluvial wash from upland areas occupied by sedimentary rocks, but, unlike the Yolo soils, are typically dark gray to black in color, with variations of dark brownish gray. The subsoils are lighter colored than the surface soils, often being gray, dark gray, or brownish gray in poorly drained places or grayish brown or brown in areas of better drainage. The subsoil, which is typically without hardpan or other compact layers, may be similar to the surface material in texture or may consist of alternating strata of variable texture. The soils are high in organic matter. Soil and subsoil typically are free from concentrations of lime, but the latter in some of the flatter areas contains calcareous nodules and seams. The Dublin soils occupy alluvial fans, stream bottoms, flats, or terraces, usually well drained, except during overflows or in some flatter parts during the rainy season. The Dublin series is inextensive in the Anaheim area, and is represented by a single type, of heavy texture. Some of the other recent alluvial soils of the area as mapped contain small undifferentiated bodies of the dark-colored soil of this series.

The Chino soils consist of somewhat modified recent alluvial material, being in most cases similar in origin to the Hanford series. They are typically brownish gray, dark gray, or black. In some places the soil is light colored when dry but much darker when wet. These soils usually are micaceous, friable, and easy to till, except in puddled, heavy-textured areas. The subsoil may be similar to the surface soil in texture or may consist of strata of different textures. It is distinguished by its calcareous nature and its tendency to dry to an ashen gray color. The soils are high in organic matter and also are frequently calcareous. The quantity and character of the calcareous material in the subsoil is subject to wide variation; there may be only a few calcareous concretions in certain strata or there may be extremely calcareous or marly beds, approaching in places a hardpan. The Chino soils occupy poorly drained, flattened margins of extensive alluvial fans, the upper and better drained parts of

which usually are occupied by soils of the Hanford series. They are often subject to overflow, and a high water table, with accumulations of alkali, is common over much of the series. The Chino series is comparatively extensive in the Anaheim area. Four types in the series are recognized. As mapped, the soils are subject to minor variations. Much of the series has a brownish color, and is difficult to differentiate from the soils of the Hanford series, into which it merges. Some areas on the lower extensions of fans occupied by the Yolo soils contain only small quantities of the material ordinarily giving rise to the Chino soils.

Miscellaneous materials.—The miscellaneous materials mapped are Muck and Peat, Tidal marsh, Coastal beach and Dunesand, Riverwash, and Rough broken and stony land. With the exception of Muck and Peat, these are essentially nonagricultural. The following table gives the actual and proportional extent of the several soils mapped in this survey:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Hanford fine sandy loam	47,360	14.9	Ramona sandy loam	5,440	1.7
Hanford sandy loam	29,056	9.2	Tidal marsh	5,312	1.7
Rough broken and stony land	28,288	8.9	Chino silty clay loam	5,056	1.6
Yolo loam	27,456	8.6	Chino silt loam	4,480	1.4
Ramona loam	19,840	6.7	Ramona gravelly loam	3,072	1.0
Reddish-brown phase	1,280		Altamont clay adobe	3,008	1.0
Ramona fine sandy loam	15,360	4.8	Yolo clay adobe	2,560	.8
Yolo clay loam	14,720	4.6	Riverwash	2,432	.8
Altamont loam	13,504	4.5	Antioch clay adobe	2,368	.7
Gravelly phase	704		Montezuma clay loam adobe	2,304	.7
Chino silty clay	10,880	4.1	Montezuma clay adobe	1,728	.5
Heavy phase	2,368		Dublin clay adobe	1,664	.5
Hanford sand	11,392	4.0	Coastal beach and Dunesand	1,344	.4
Coarse phase	1,152		Muck and Peat	1,024	.3
Altamont clay loam	12,224	3.9	Ramona sand	960	.3
Hanford loam	10,816	3.4	Diablo clay adobe	832	.3
Ramona clay loam	9,152	2.9	Altamont clay	704	.2
Chino clay loam	6,080	1.9	Total	317,440	.....
Yolo fine sandy loam	5,888	1.9			
Altamont fine sandy loam	5,632	1.8			

ALTAMONT FINE SANDY LOAM.

The soil of the Altamont fine sandy loam consists of a grayish-brown to brown, medium to heavy textured fine sandy loam, ranging from 12 to 24 inches in depth. The subsoil is a brown or yellowish-brown compact loam or clay loam, underlain at a depth of 2 to 5 feet by the parent rock, consisting of soft sandstones and shales. The surface soil usually is very friable. It is not so retentive of

moisture as the heavier textured soils of the same series, but probably is slightly more absorptive. The subsoil is more compact and retains moisture well, the light-textured surface material acting as a mulch. The content of organic matter is lower than in the case of the heavier members of the series. The subsoil and the rocks underlying the type frequently contain lime in varying quantities. Rock outcrop is frequent over parts of the type.

Portions of this type usually are associated with conglomerate rocks, giving rise to gravel or bowlders on the surface. This material is most abundant on knolls or ridge crests, where the gravel may constitute from 5 to 30 or 40 per cent of the soil mass. This gravelly variation differs in water-holding capacity and agricultural value from the main bodies of the type.

The Altamont fine sandy loam varies from place to place in texture and depth and to some extent in color and structure. While the color is generally grayish brown or brown, several small areas along the boulevard to Laguna in the southern part of the survey are reddish brown. On ridges or hilltops the surface soil in local areas ranges from a gravelly sand to heavy sandy loam and shows but little uniformity. Other bodies grade locally into a fine sand, or sand on the one hand and into a light loam on the other. Several large areas in the vicinity of El Toro are finer textured and deeper than the average, with a smoother surface and higher content of organic matter. The heavier variations result from the washing of the lighter surface soil from steep slopes. The variations in the texture of the type usually are of minor consequence, and the areas in which they occur are too small to indicate on the soil map. Variations in structure accompany the differences in texture, the heavier material generally having a more compact structure. The combined depth of soil and subsoil vary greatly, depending on the topography. The deepest soils occur on the gently rolling tops of ridges and around the base of the hills where material has accumulated from the higher slopes through local creep. Both soil and subsoil are shallower in the steeper and eroded parts of the type, and here the bedrock is often exposed.

Small, irregular areas of the Altamont fine sandy loam are mapped in the hilly parts of the survey. Several bodies occur in the regions north and south of La Habra, and several areas are mapped in the eastern and southeastern parts of the survey and in the vicinity of El Toro with others along the southern boundary, including those east of Newport Beach.

The type has a gently rolling topography, with frequent rough and hilly areas and eroded steep ravine slopes. Over the smoother parts the surface is favorable to irrigation, provided water can be obtained, but over the remainder irrigation is impracticable. The

drainage is in general good, the areas of lighter texture or steeper slope being excessively drained and droughty.

Owing to its small extent, this type is relatively unimportant. From 25 to 50 per cent of it is cultivated, the rest being used for pasture. The rougher slopes and unused areas support a growth of brush. The most important crops are grain and beans, with grain occupying the greater part of the cultivated land. Most of the grain consists of barley grown for hay under dry-farming methods. Near El Toro the type is used for grain production, but the yields are light, owing to drought. Summer fallowing to conserve the moisture is needed on this type more than on the heavier soils of the series. Beans are grown on the slightly heavier variations of the type, and the yields are good. They are grown on the same land year after year, the fields being extensions from the adjoining lower lying recent alluvial soils. In general, yields are fair, but lighter than on the heavier members of the series. It is reported that the bean crop tends to improve in yield as nitrogen and humus are added to the soil by growing the crop.

The results of mechanical analyses of samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Altamont fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574254	Soil	2.8	7.8	6.2	24.8	33.5	17.2	7.4
574255	Subsoil	2.2	4.2	3.2	11.2	32.2	19.7	27.5

ALTAMONT LOAM.

The Altamont loam is a brown, somewhat gritty loam, which varies in depth, but is generally underlain at about 12 inches by a lighter brown or yellowish-brown loam or clay loam subsoil. Bedrock usually is encountered at a depth of less than 6 feet. The soil is generally friable, moderately low in organic matter, and in places calcareous. It is fairly retentive of moisture in the deeper areas, but droughty where shallow. The subsoil typically is more compact than the surface soil. Much of it contains moderate quantities of calcareous material and shows an adobelike structure or exposure. Samples of the soil and subsoil collected about 2¾ miles southeast of El Modena contained 1.15 per cent and 4.63 per cent, respectively, of lime ($CaCO_3$). Outcrops of bedrock occasionally occur, and usually are weathered into rounded forms.

The Altamont loam is more variable in texture than the Altamont clay loam. As mapped it includes small areas of a gravelly sandy

loam, and of a light clay loam. The typical brown color gives way to a light grayish brown, darker brown or reddish brown in small areas. Like the other residual soils, the type varies greatly in depth of soil and subsoil. The shallower soil usually occurs in the rougher and steeper areas, and the subsoil may be entirely absent where the bedrock lies close to the surface. The type averages deeper in this area than in other surveys, and the bedrock frequently occurs at depths of more than 6 feet.

The Altamont loam occurs throughout the hilly and mountainous parts of the area, largely in the northern, eastern, and southeastern sections. The areas are for the most part irregular and small but several large areas lie east and south of Irvine and in the vicinity of El Toro. The type is not readily distinguished from adjoining soils of the same series, and the boundaries in some cases are more or less arbitrary.

This is a rolling to steep and hilly type, although small areas are smooth. The surface is generally dissected by ravines or canyons. Some of the crests of ridges are fairly level. Some parts of the type are too rough for cultivation, and it is generally not well adapted to irrigation. The soil is well drained and the run-off usually very rapid.

About one-third of the type is tilled, the rest being used for pasture. Grain and grain hay are the principal crops, while a small acreage of beans is planted in the southeastern part of the area. Small citrus orchards have been set out and irrigated with pumped water. Some eucalyptus plantings have been made on the rougher parts of the type. Unused areas ordinarily are covered with brush. Yields of grain and hay from this type average lighter than from the heavier soils of the series. Land values vary greatly.

Altamont loam, gravelly phase.—The Altamont loam, gravelly phase, does not differ essentially from the typical soil, except in gravel content. It usually consists of a brown, light-brown, or sometimes slightly reddish brown loam, containing moderate to large quantities of rounded or subangular gravel ranging up to about 3 inches in diameter. The gravelly soil ranges from a few inches to 2 or 3 feet in depth, and normally is underlain by a heavier textured subsoil of brown or slightly reddish brown color. The subsoil rests upon the parent rock, which is either a conglomerate or sandstone and conglomerate interbedded. The soil seems rather low in organic matter. Concentrations of lime sometimes occur in the subsoil. Some of the phase is probably a weathered product from unconsolidated or partially consolidated water-laid material, and in point of origin is not true Altamont material. Other parts are intermediate in this respect between the residual soils and the old valley-filling soils.

The most important areas of the phase are in the region east of Olive, with bodies of less importance northwest of Yorba Linda and northeast of Irvine. The surface usually is rolling, steep, or somewhat dissected; some parts resemble an elevated, dissected plain. Drainage is good. Subdrainage is favored by the rather porous character of the material.

The soil is not very important agriculturally, owing to its topography, its elevated position, and unfavorable textural characteristics. Irrigation is difficult. Grain hay is practically the only crop grown. Most of the land is used for pasture.

ALTAMONT CLAY LOAM.

The Altamont clay loam is a brown to grayish-brown, rather compact clay loam, ranging in depth from 12 to 24 inches. The subsoil typically is lighter in color than the surface material, having various shades of brown, and usually consists of a clay loam or clay. This subsoil passes at depths of 24 to 60 inches or more into the weathered soft sedimentary rocks from which the overlying material is derived. The color of both soil and subsoil averages darker than typical Altamont loam, and the type seems to contain more organic matter. The subsoil frequently is mottled with seams of calcareous material. Some rock outcrop occurs, but this has little influence on the character of the soil.

The Altamont clay loam is subject to many variations. While the color is generally dark brown, a number of small reddish-brown areas are included, with others which vary from a light grayish brown to the darker typical colors. The lighter color usually is associated with shallow soils on the tops of knolls. Small bodies of darker color, resembling somewhat the Diablo soils, often occur on the lower slopes.

The Altamont clay loam, while compact in structure and usually of good water-holding capacity, is moderately friable. Some of its variations have an adobe structure. The type as a whole is subject to considerable variation within single bodies. In many places where the soil is shallow there is no distinct subsoil. The soil is deepest along foot slopes and across minor swales, where considerable colluvial material has accumulated. Boundaries between this and associated types are in places largely arbitrary.

The Altamont clay loam is an important soil. It occurs throughout hilly regions in the northern, eastern, and southeastern parts of the area. The largest areas lie in the southern and southeastern parts of the survey. The type often covers the crests or smoother slopes of hills, the remaining parts being occupied by Rough broken and stony land or by other types of the Altamont series. The surface is rolling or steep and hilly, in many cases unsuited to irrigation. It is sometimes washed and dissected, but the main slopes

do not erode badly. The surface drainage is good and the subdrainage generally good, except in small spots subject to seepage.

Probably more than one-half the type is tilled. A small part too rough for cultivation is covered with brush and used for pasture. Grain, grain hay, and beans are the most important crops, grain occupying the greatest acreage. The soil is retentive of moisture and these crops do well without irrigation. Small areas are used for citrus fruits, water for irrigation being supplied by pumping, but the land is mainly dry farmed. Where grain is grown the soil is summer fallowed in alternate years. Beans usually are grown continuously, but in some cases the crop is rotated with grain.

The soil is plowed at the time of the first fall rains and is put in good condition before the seed is sown. For beans, particularly, the land is thoroughly cultivated and practically freed from weeds before planting, after the last spring rains. Growers say the land used for beans becomes steadily more productive with continued use. The yields of barley are about equal to the average for the region.

The price of land of this type varies widely. Where beans and citrus fruits can be grown it is held at several hundred dollars an acre. Much of the Altamont clay loam is in large holdings and is farmed by tenants under the supervision of trained overseers.

The results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Altamont clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574244	Soil	0.1	0.2	0.4	4.2	30.4	39.0	25.6
574245	Subsoil	.0	.2	.2	2.9	28.8	44.6	23.6

ALTAMONT CLAY.

The Altamont clay is a dark-brown or dark grayish brown, sticky, but light-textured, clay, underlain by a compact clay subsoil of lighter brown color. The soil varies in depth from 8 to 24 inches, and the subsoil extends to a depth of 3 to 4 feet or more where the bedrock, consisting of soft shales and sandstones, is encountered. This bedrock occasionally is exposed as rock outcrop. Both surface soil and subsoil are very compact and crack upon drying, but are friable, considering their heavy texture. A fair percentage of organic matter occurs in the soil, and seams of calcareous material frequently are found in the subsoil. Both soil and subsoil are fairly retentive of moisture.

As with the other types of the Altamont series, the soil varies slightly in texture, color, and depth at different elevations. It is

somewhat lighter in color and in texture near the tops of the hills than at the base, where it is deeper and cracks more on exposure in dry seasons.

The Altamont clay occurs only in the northeastern part of the area, where it adjoins bodies in the Pasadena area. It is of little agricultural importance because of its small extent. The hills over which the type occurs are rounded, and the slopes, though rather steep, are generally smooth enough for tillage. The surface is not adapted to irrigation. Surface drainage is rapid and subdrainage good.

About 30 per cent of this type is used for the production of barley hay and the remainder as pasture.

Yields on this type are about the same as on the Altamont clay loam, and similarly located bodies of these soils are held at about the same price.

ALTAMONT CLAY ADOBE.

The Altamont clay adobe typically consists of a brown to dark-brown, rather friable clay of adobe structure, from 12 to 24 inches in depth, underlain by brown to light-brown, compact clay loam or light clay, which at depths of 2 to 5 feet passes into the parent bedrock. This in many places consists of soft shales and other sedimentary rocks that weather rapidly. The soil generally contains a large percentage of organic matter, and is capable of storing considerable moisture. Small seams of calcareous material are common in the subsoil, and both soil and subsoil frequently are calcareous. A sample of typical soil of this type to a depth of 14 inches, taken $1\frac{3}{4}$ miles northeast of La Habra contained 1.81 per cent of lime ($CaCO_3$), and a sample of the subsoil, taken to the bedrock substratum which occurred at a depth of 40 inches, contained 5.38 per cent. The harder beds of the parent rock sometimes outcrop.

The Altamont clay adobe, as mapped in this survey, includes small areas of brown to black soils derived from basic igneous or metamorphosed rocks; these soils represent material of the Olympic and Climax series, but the area is too small to warrant separation.[1]

[1] The Olympic and Climax material is of less friable character than the Altamont, and becomes very sticky and puddled when wet. It checks and cracks upon drying and assumes a pronounced adobe structure. This material varies considerably in depth, being in the shallower areas less than 18 inches deep and underlain by the parent rock without a distinct subsoil. The deeper areas have a distinct subsoil at about 12 to 18 inches, which usually is lighter in color and frequently lighter or more gritty in texture than the surface material, often carrying partially weathered fragments of the parent rocks. The combined depth of soil and subsoil of these Olympic and Climax areas is rarely more than 3 or 4 feet, often being greatest along the foot slopes of hills and in places where colluvial material has accumulated. The subsoil rests upon a substratum of igneous massive rock or breccia, the weathering of which gives rise to the soil. Angular rock fragments and bowlders sometimes occur on the surface, increasing in quantity near bodies of Rough broken and stony land. The soil seems to be fairly high in organic matter. Some of the areas are stony; others free from stone and smooth.

The Altamont clay adobe is generally uniform, but some variations occur in texture and depth of soil as well as in color. The type sometimes occupies the lower hill slopes, the higher slopes being covered with soils of lighter texture. Local creep of soil material is responsible for a greater depth of the soil at lower elevations. A reddish-brown variation is included with the type, but is of small extent.

The Altamont clay adobe occurs in very irregular bodies, and sometimes encircles the base of a hill or extends over the saddles of adjoining hills. The type forms several relatively small areas near La Habra and Brea, in the northeastern part of the survey, and west of El Toro, southwest of Irvine, and northeast of Newport Beach. The included Olympic and Climax soils are confined to some small areas east and southeast of El Modena. The surface of the Altamont clay adobe is in general sloping to rolling or hilly and in some places eroded and steep, making cultivation difficult. There are some moderately smooth areas, suitable for irrigation if water can be obtained. The type is well drained in both soil and subsoil, but because of its heavy texture it absorbs moisture slowly, and the run-off usually is excessive. Local seepage spots sometimes appear in the wet season.

This type is relatively unimportant because of its small extent, but local areas are good dry-farming land. It seems to hold moisture better and to produce better grain crops than most of the other types of the series. The greater part is farmed, being devoted to barley, which is grown for both hay and grain. The yields are above the average for the grain-growing lands of the area. A small part of the type is used in the production of beans and citrus fruits, and some of it as pasture. The price of the land varies widely, and usually is influenced by that of associated soils.

The results of mechanical analyses of typical samples of the soil and subsoil of the Altamont clay adobe are given in the following table:

Mechanical analyses of Altamont clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574234	Soil	0.7	1.1	0.6	6.8	13.9	41.3	35.5
574235	Subsoil	.6	1.2	.6	6.4	14.8	39.6	36.7

DIABLO CLAY ADOBE.

The surface soil of the Diablo clay adobe is dark green to black. The subsoil is usually lighter colored than the surface material, but

may be dark gray. The surface of moist fields usually has a brownish tint. Typically the soil is from 12 to 30 inches deep and the subsoil usually extends to a depth of 4 feet or less, being underlain by bedrock, which consists of shale or rarely of impure limestone. The surface soil is a sticky, compact, heavy clay of adobe structure which checks into rough blocks separated by wide, deep cracks when dry and uncultivated. This cracking exposes plant roots to the air and increases the loss of moisture, but where properly tilled the soil is granular and retentive of moisture. The dark color of the surface soil indicates a high content of organic matter. The subsoil is calcareous. The surface soil may be calcareous, but it is less uniformly so than the subsoil. Typical samples of soil and subsoil collected about 3¼ miles southwest of El Toro showed no unusual indications of lime in the surface soil to a depth of 20 inches. The subsoil underlying this and extending to the parent bedrock, which was encountered at a depth of 48 inches, contained 1.75 per cent of lime in the form of calcium carbonate.

The Diablo clay adobe is rather uniform in this area, the principal variations being where it merges with other types of residual character. Here the soil is lighter in color, has a somewhat lighter texture, and in places contains gravel and small bowlders. The soil of the small areas east of Olive is much deeper than typical and underlain by subsoils of light-brown color. Parts of these areas, as well as some of the type in other places, contain material derived from unconsolidated materials, thus resembling in origin the Montezuma clay adobe.

The Diablo clay adobe is inextensive in this area. It occurs mainly in small bodies about 3 miles southwest of El Toro in the extreme southeastern part of the survey and east of Olive, and in others several miles east of Newport Beach.

Most of the type in this area has a more subdued and uniform topography than in other parts of the State. The surface also is more regular than that of other residual types in the Anaheim area. The topography in practically all cases is favorable for irrigation if water can be obtained. Little rock outcrop occurs. Both the soil and the subsoil are well drained.

The Diablo clay adobe is of relatively little agricultural importance. Practically all of it is used for grain production, with a small part devoted to beans. Where grain is grown, fallowing is practiced as with the soils of the Altamont series. The yields are good, better than the average for the residual soils of the area.

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The results of mechanical analyses of typical samples of the soil and subsoil are given in the following table:

Mechanical analyses of Diablo clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574256	Soil	0.9	1.4	1.0	6.0	7.6	31.4	51.7
574257	Subsoil	1.1	1.6	.8	3.3	8.1	28.0	57.0

RAMONA SAND.

The Ramona sand is a light-brown to slightly reddish brown loamy sand which passes gradually at depths of 24 to 36 inches into a slightly heavier and somewhat more compact subsoil of about the same color as the surface. When moist both surface soil and subsoil are a more intense reddish brown. The subsoil is less compact and distinct from the surface soil than that of the other members of the Ramona series. The type has an open, loose, friable structure and a low content of organic matter, although the material is fairly retentive of moisture for a soil of such light texture.

The Ramona sand is inextensive and subject to little variation. Only a few areas are found; the largest is at Newport Heights, two small areas lie near Huntington Beach, and one at Corona del Mar.

The Ramona sand has a gently undulating surface well adapted to irrigation, although some leveling usually is necessary. It occurs in the higher parts of the coastal-plain section. It is well drained and in irrigation large quantities of water are necessary to produce good crops.

The Ramona sand is not an important agricultural soil, although the large area on Newport Heights is intensively farmed. The two small areas at Huntington Beach are not used for agriculture, as they lie within the limits of the city. Apples, lemons, oranges, walnuts, and truck crops are grown in the area at Newport Heights. The farms are usually small. Alfalfa and some grain are also grown on the type. Many of the orchards have not yet come into bearing. The average yields of some of the crops where plenty of water is applied are good. Barnyard manure and fertilizers of all kinds are used. Green manuring has proved beneficial.

The price of land of this type is generally high, as most of it is either within the limits of a town or is semiurban property.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil:

Mechanical analyses of Ramona sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574248	Soil	2.0	17.4	11.8	41.6	13.4	9.3	4.5
574249	Subsoil	1.8	15.2	11.0	42.6	12.2	11.4	5.9

RAMONA SANDY LOAM.

The surface soil of the Ramona sandy loam is a brown, light-brown, or slightly reddish brown sandy loam to rather coarse sandy loam, from 12 to 18 inches or more in depth. The subsoil is distinct from the surface material, having a heavier texture and more compact structure. It is brown or reddish brown in color, and may extend to a depth of 6 feet or more or may be underlain at 4 or 5 feet by more friable, somewhat lighter textured strata. The subsoil is relatively impervious, and root development is limited largely to the more friable surface material. The surface soil is moderately loose and friable when moist and cultivated. The organic-matter content usually is low, and the soil bakes when exposed to hot, dry weather without tillage. Calcareous seams are sometimes found in the subsoil and deeper substrata. Local areas carry gravel and bowlders, as in parts of the large area of the type near El Toro, where the subsoil also is gravelly in places. Lenses of hardpan are encountered occasionally, but are of small extent. Some of the subsoil is so compact that it resembles hardpan. Strata of sand, silt, and clay, characteristic of the substrata of the Ramona series, underlie the type. The absorptive capacity of the soil is low, and depends largely upon the depth to the compact subsoil. Much of the type is droughty, and here good crops can not be produced without irrigation.

The Ramona sandy loam is subject to minor variations, chiefly in texture and depth of the surface soil. The large area at El Toro is of coarser texture and the surface soil generally more shallow than the average, while small areas are underlain by soft sedimentary rocks within 6 feet of the surface This area also contains some heavier textured and darker colored material. The area about 3 miles northeast of Newport Beach is of light texture, approaching a loamy sand, and of greater depth than typical. In some of the smaller bodies on the high terraces along the coast marine shells are found.

The Ramona sandy loam forms several large areas of irregular outline and a number of smaller, more regular bodies. The principal area is that at El Toro. Areas of fair size lie on the terrace

northeast of Newport Beach, northeast of Placentia, and at Huntington Beach, and small areas in the vicinity of Alamitos Bay and southeast of Yorba Linda.

The greater part of the surface of the Ramona sandy loam is gently sloping, fairly smooth, and moderately well adapted to irrigation. Some of the ravine sides are cultivable, but difficult to irrigate. Surface drainage is well established, but subdrainage is not thorough, the heavy, compact subsoil retarding percolation to some extent. This is less pronounced, however, than in the fine sandy loam and loam members of the series. The Ramona sandy loam is an important soil, but less so than the Ramona fine sandy loam. About 75 per cent of the type is under cultivation, the remainder being used for pasture or for building sites.

Grain and grain hay, largely barley, constitute the principal crops. Some beans are grown, particularly north of El Toro. Some olives and eucalyptus also are grown near El Toro. Little of the type is irrigated, and the quantity of fertilizer applied to the land is negligible. Crop yields are not above the average. The price of land of this type ranges up to several hundred dollars per acre.

The results of mechanical analyses of samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Ramona sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574258	Soil	11.6	14.6	6.4	23.4	19.8	18.2	6.2
574259	Subsoil	3.4	8.2	4.2	20.6	20.1	22.9	20.2

RAMONA FINE SANDY LOAM.

The Ramona fine sandy loam typically consists of a light-brown, brown, or slightly reddish brown, moderately friable fine sandy loam, 12 to 24 inches in depth. The subsoil is a very compact and relatively impervious fine sandy loam to clay loam extending to depths of 48 to 72 inches or more, where in many places it gives way to a more friable substratum. The prevailing color of the subsoil is brown or slightly reddish brown, but a yellowish-brown or mottled color is common. Change in texture from soil to subsoil is abrupt. The latter where exposed is hard and adobelike. The Ramona fine sandy loam contains little organic matter. It is fairly absorptive of water, but retains moisture poorly, loss by evaporation being rapid. The surface of the heavier areas bakes upon drying without cultivation. Small concentrations of lime occasionally exist in the subsoil, mainly in marginal areas of the type. A sample of the subsoil

between the depths of 12 and 70 inches, taken about three-fourths mile southwest of Harper, contained 0.43 per cent of calcium carbonate, but the entire soil column usually is free from conspicuous calcareous material. The more friable substratum has little effect on crop production.

The Ramona fine sandy loam as mapped includes many variations which are not sufficiently extensive to warrant separation as soil types. The texture varies from a fine sand to a light loam. The depth of the surface soil is variable, but usually shows a relation to texture, being deeper and more open and friable in the lighter textured areas. Gravel and coarse material are uncommon. Hardpan is not typically found in the soil section, but lenses occur locally. In marginal or local areas, where the type occurs near the ocean, varying quantities of marine shells are found, this condition often accompanying a darker color of the soil, especially where the type merges with material of the Antioch or Montezuma series. Small parts of the type adjacent to some of the residual soils are underlain by bedrock at depths of several feet.

The Ramona fine sandy loam occupies old coastal plain or alluvial fan remnants. The areas usually are irregularly shaped, but the boundaries are generally well defined, owing to pronounced topographic or color differences. In some instances, however, the type merges gradually with the heavier or lighter members of the same series. The principal areas lie along the ocean front and inland from Newport Beach. Other important areas occur near La Mirada, Brea, and Placentia, and several small areas are situated in the eastern part of the survey.

The topography of the Ramona fine sandy loam is that of a generally uniform or slightly undulating plain, ususally well elevated above the recent alluvial deposits and dissected by a well-established system of drainage. Some areas occupy sloping remnants of old alluvial fans, and the type, as a whole, is in process of erosion. The topography is fairly well adapted to irrigation, but in the least favorable part of the type it is difficult to provide a uniform distribution of water. Some gullies and ravines occur, which, especially in their lower courses, are steep and deeply cut. The drainage of the surface soil is fairly well established, but the impervious subsoil retards percolation. Local shallow, inclosed depressions occur in places, and retain surface water until it is removed by evaporation or slow percolation.

The Ramona fine sandy loam is an important soil in the agriculture of the area, and with the exception of some parts of the areas overlooking the ocean, used for building sites, is mainly tilled. Dry-farmed grain is grown on the greater part of the cultivated land. Some irrigated areas are used in the production of alfalfa and beans.

A great variety of crops, including lemons, oranges, walnuts, apples, apricots, peaches, and truck are grown in small acreages on Newport Heights—small quantities of irrigation water being used. Most of the orchards in this section are young. Citrus fruits, walnuts, olives, and other fruits are grown on some of the type in the northern part of the area. A growth of brush, such as formerly covered the greater part of the type, occupies the rougher portions.

Where the soil is not irrigated the yields of grain are low—at least not above the average for the area. Alfalfa is irrigated and does moderately well. Beans give fair yields. Beans, grain, and alfalfa are produced without the use of fertilizer, but the orchards are given applications of stable and green manures as well as commercial fertilizers.

The Ramona fine sandy loam ordinarily is deficient in organic matter; and, because of its open, porous nature, requires the frequent addition of materials even to maintain the supply. The plowing under of stubble, green manure, or stable manure results in an increase in crop yields and in an improvement in the power of the soil to hold water. The growing of beans and alfalfa is beneficial. This is particularly noticeable where these crops are followed by grain.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Ramona fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574250	Soil	1.2	6.4	4.8	20.8	24.6	32.5	9.9
574251	Subsoil	.9	5.6	4.6	20.8	19.4	21.8	26.9

RAMONA GRAVELLY LOAM.

The surface soil of the Ramona gravelly loam is a brown to reddish-brown gravelly loam, 12 to 15 inches deep. The gravel is rounded to subangular in shape and constitutes from 10 to 20 per cent or more of the soil mass. The subsoil is fairly distinct from the surface material, but less so than in the loam and fine sandy loam types of the series. It usually is a reddish-brown, compact gravelly loam or clay loam, underlain by a gravelly substratum of lighter color and texture. The finer soil material is generally sticky when wet and compact when dry, but the gravel renders the type friable, without hindrance to cultural operations. The soil is fairly retentive of moisture. The Ramona gravelly loam does not vary greatly except in the quantity of gravel present. This type, like the Ra-

mona loam, is often slightly reddish brown when wet, but becomes brown upon drying.

The type is of comparatively small extent, and is confined largely to areas in the vicinities of Orange, Wanda, and El Modena. The larger bodies bordering Santiago Creek have been modified by recent alluvial agencies.

The topography is smooth, gently sloping, or gently undulating, and well adapted to irrigation. The drainage is good, except that percolation takes place slowly through the subsoil.

Practically all the type is tilled and used mainly for citrus fruits and grain. Medium to good yields are obtained.

The condition of this type has been improved and its power to absorb and retain water increased by the use of fertilizers, manure, and the plowing under of cover crops. The average price of land of this type is high. It depends mainly upon improvements and location.

RAMONA LOAM.

The Ramona loam consists of 10 to 20 inches or more of a brown or slightly reddish brown compact loam, underlain by a subsoil consisting of a very compact brown or reddish-brown clay loam or clay which extends to a depth of 40 to 60 inches or more. This in turn often gives way to a lighter colored substratum, usually of lighter texture and more friable structure, which extends to an undetermined depth. The soil contains a small percentage of organic matter under ordinary conditions, but in the zone of transition to heavier members of the series or to soils of the Montezuma series it contains a larger percentage, as is indicated by the darker color of the soil. The surface soil is compact, and the uncultivated surface bakes when dry. It is only moderately absorptive and retentive of moisture. The subsoil is flinty, relatively impervious, and cracks upon exposure. Roots penetrate the upper part of the subsoil with difficulty. Both soil and subsoil usually are free from concentrations of lime, but seams and other concentrations occasionally are found in the subsoil. Samples of this type collected one-half mile west of Yorba Linda showed in the subsoil, between depths of 20 and 60 inches, 0.79 per cent of lime ($CaCO_3$).

In this type there is some variation from the typical in color, texture, and structure, though as a rule the variations in color are not distinct. In marginal areas where the type adjoins the Ramona clay loam the color is often dark brown. A silty variation is included in some of the larger bodies. The structure of the soil is rather uniform, but some minor depressions have a surface soil which is more compact than typical. Small quantities of gravel occur where the type grades into gravelly soils, especially near the

foothills in the northern part of the survey. Restricted areas, such as parts of the body north of Huntington Beach, carry concentrations of lime in the subsoil. Such variations resemble the soils of the Antioch series, but are too small to be separated on the soil map. Marine shells are sometimes present on the surface near areas of the Montezuma soils or along the ocean bluffs.

The Ramona loam is widely distributed. Large areas are mapped in the northern and eastern parts of the survey. Several important areas occur on terraces facing the ocean.

The Ramona loam is similar to the other types of the series in occurrence, and occupies parts of old dissected alluvial fans lying along the hills and marine terraces bordering the ocean. These remnants of earlier surfaces are generally elevated above, and more diversified than, the more recent alluvial plains, from which they are often separated by distinct bluffs. The surface is smoothly sloping or undulating to rolling, and is sometimes traversed by gullies and stream channels. For irrigation leveling usually is necessary, but is not difficult where the furrow system is used. Regional drainage is well established. The run-off normally is rapid, but the dense nature of the subsoil retards subdrainage. Pools of water occupy local depressions during wet seasons, the water remaining until evaporated or slowly removed by percolation.

The Ramona loam is an extensive and important soil, and practically all of it is farmed. Dry-farmed grain and grain hay are the most extensive crops. Beans are produced along the coast and to a small extent farther inland. Irrigation has been supplied in many places and important plantings of oranges, lemons, and other fruits have been made. Other irrigated areas are used for the production of truck crops. The general tendency is to extend irrigation and intensify the use of the soil. Yields under dry farming are somewhat better than on the lighter textured soils of the series. Irrigation is necessary for alfalfa, fruits, and nuts, and fair yields are obtained, except where the compact subsoil restricts root growth. Stable manure, green manure, and commercial fertilizer are applied in the orchards.

The price of land of this type varies widely with the location, the improvements, the crop occupying the soil, and the possibility of irrigation. Along the coast the price of some of the land is influenced by its value for building sites.

The Ramona loam has a low content of organic matter and a relatively impervious subsoil. The incorporation of stable manure, green manures, and other forms of organic matter is needed to improve the physical condition of the soil, and in some cases it may be profitable to use explosives to shatter the subsoil.

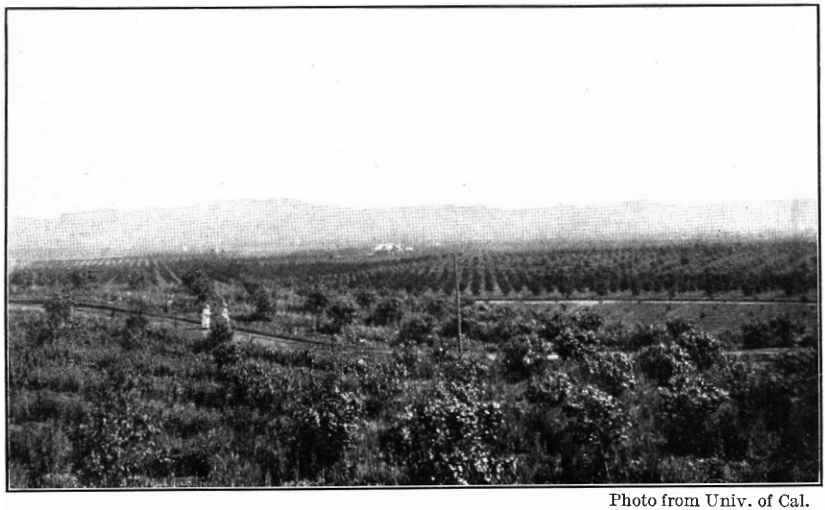

Photo from Univ. of Cal.

FIG. 1.—ORANGE AND LEMON ORCHARDS ON SOILS OF THE RAMONA AND YOLO SERIES EAST OF LA HABRA.

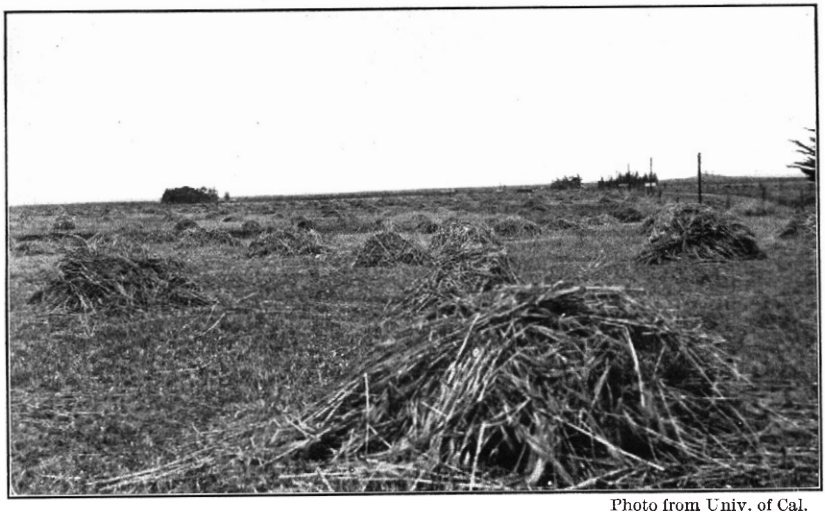

Photo from Univ. of Cal.

FIG. 2.—BARLEY HAY GROWN ON THE RAMONA LOAM, NEAR HARPER.

FIG. 1.—ENGLISH WALNUT GROVE ON SOILS OF THE RAMONA SERIES NORTHEAST OF FULLERTON.

Photo from Univ. of Cal.

FIG. 2.—SUGAR BEETS ON CHINO SILTY CLAY LOAM EAST OF HUNTINGTON BEACH.

Ramona loam, reddish-brown phase.—The reddish-brown phase of the Ramona loam consists of a reddish-brown loam, 12 to 18 inches deep, underlain by clay loam or clay of the same color, which extends to depths varying from 36 to 60 inches. Below this material a more friable, lighter colored substratum exists in many places. The phase differs little from the typical loam, except in color. A sample of the subsoil collected 1½ miles northeast of Orange and representing the material between depths of 14 and 36 inches, contained 0.79 per cent of lime in the form of calcium carbonate. Gravel may occur in both soil and subsoil along the zone of contact with the Ramona gravelly loam.

The phase is inextensive. The principal areas lie northeast, southeast, and northwest of Orange, and small areas in the vicinity of El Modena, northeast of La Habra, and east of Brea.

Part of the land is devoted to dry-farmed hay and grain, but most of it is used in the production of citrus fruits. Crop yields and cultural methods are the same as on the typical soil.

The results of mechanical analyses of samples of the soil and subsoil of the Ramona loam and of its reddish-brown phase are given in the following table:

Mechanical analyses of Ramona loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574228	Soil	3.2	5.4	3.8	13.8	25.8	37.0	11.5
574229	Subsoil	4.7	6.4	3.2	13.6	16.2	30.0	25.9
Reddish-brown phase:								
574238	Soil	1.0	3.4	2.2	12.0	23.9	42.8	14.8
574239	Subsoil	1.4	2.8	1.8	10.6	20.0	32.5	30.9

RAMONA CLAY LOAM.

The Ramona clay loam is subject to wider color variations than the other types of the series, but typically consists of a brown or dark-brown friable clay loam with a tendency to adobe structure. It is somewhat sticky and intractable when only moderately wet, and becomes baked and very hard and flinty when exposed to dry weather without cultivation, although it may be handled under a wider range of moisture conditions than the clay adobe soils of the area. The soil is fairly receptive and retentive of moisture where cultivated, and apparently is rather high in organic matter. At depths ranging from 12 to 24 inches or more a distinct subsoil occurs. This is light brown, reddish brown, or mottled, and similar to or heavier than the surface soil in texture. The subsoil characteris-

tically is very compact, and cracks and hardens in dry weather when exposed. The difference in texture between the soil and subsoil is not so marked as in other types of the series, but the subsoil and substrata show distinct evidence of modification by aging, in which they differ from the subsoil and substrata of typical recent alluvial soils. The subsoil is less favorable for deep-root development than that of recent alluvial soils of similar texture. In some places the lower subsoil from about 4 feet downward is more friable and slightly lighter textured than the dense upper subsoil. Both the subsoil and substrata usually are free from concentrations of lime, but some exposures near La Habra and elsewhere through the type show such concentrations, and included areas of this kind, usually occurring along the margins of areas, might properly be classed with the Antioch series. Determinations of the lime content of samples collected about one-half mile north of La Habra indicate that the surface soil contains 0.50 per cent of lime ($CaCO_3$).

The type includes several variations. The typical color, which averages darker than that of other types of the series, is in places dark grayish brown or very dark brown, the soil resembling in this respect types of the Montezuma series. Some areas are almost black when wet. Such bodies not only occur in flattened or slightly less well drained places but extend over gentle rises as well. Parts of the area southeast of Paularino are slightly reddish brown in color, locally a clay in texture, and of rather pronounced adobe structure. Other included areas consist of a very heavy clay loam or clay, and material of a loam texture also is included with the type as mapped. Parts of the type merge into the Yolo clay loam and have a subsoil intermediate between the Ramona and the Yolo soils. The placing of boundaries in such cases is necessarily arbitrary.

The Ramona clay loam is widely distributed but is less extensive than the loam and fine sandy loam of the series. The most important bodies occur in the northern part of the survey from the vicinity of Yorba Linda northwestward to the boundary of the area. The largest body, which is broken by associated types of the Ramona and Yolo series, extends westward from La Habra. The general region east of Orange and Santa Ana contains several areas of this soil.

The Ramona clay loam has a surface much like that of the other types of the series. Parts of the soil areas are rather smooth or only slightly uneven or undulating; elsewhere a sharply rolling, dissected surface occurs. East of Yorba Linda the surface is irregular, and it is difficult to distinguish this type from some of the associated residual soils. Gullies or sharply entrenched drainage ways are uncommon, but there are a few minor ravines, the slopes of which are

too steep for tillage. Some of the bodies are relatively flat or depressed. Drainage is normally good except in some of the flat areas or in areas of uneven surface in which depressions restrict run-off. Underdrainage is not rapid, but rarely is slow enough to produce conditions unfavorable for agriculture. Practically all the type is free from alkali, except in places along the coast where the material seems to retain soluble salts accumulated early in its formation.

The Ramona clay loam has a wide variety of uses, which depend largely upon local factors, such as frost conditions, availability of irrigation water, and situation. Some of the type around and west of La Habra is irrigated and used for the production of lemons, oranges, and walnuts. These crops and other irrigated crops are produced in other places through the northern and eastern parts of the area. Extensive plantings of olives have been made north of La Mirada. In the southern part of the survey the type is not so intensively used as elsewhere, but it is nearly all tilled—grain, grain hay, and beans being the main crops. These crops are important in all parts of the type where irrigation has not been provided. The Ramona clay loam is more difficult to till and of somewhat lower value for intensive crops than some other types in the area, but it is nevertheless a valuable agricultural soil. The tendency on this type is toward an extension of irrigation and the production of intensive crops.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of the Ramona clay loam:

Mechanical analyses of Ramona clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574236	Soil	2.0	2.7	1.4	9.8	24.2	36.9	22.5
574237	Subsoil	1.8	3.4	1.7	9.6	25.2	38.4	19.9

MONTEZUMA CLAY LOAM ADOBE.

The Montezuma clay loam adobe consists typically of a dark-gray to black clay loam of rather friable adobe structure. The soil is very sticky when wet. Upon exposure during the summer season without cultivation it bakes and assumes an adobe structure, but is easily pulverized. The type usually contains more sandy material than its cracked, refractory appearance in the field indicates, and some of the material is of rather light loam texture. The soil grades rather sharply at a depth of 18 to 36 inches into a grayish or brownish subsoil. This in some instances is heavier textured and more compact than the surface material, and usually contains calcareous material in seams or other concentrations. Typical samples of this type from near La Habra contained 1.56 per cent of lime in the form of cal-

cium carbonate. The entire soil column is fairly absorptive, and where cultivated is quite retentive of moisture.

The type has several important variations. Much of the body between Norwalk and La Habra has a pronounced brownish cast under dry field conditions, although it is classed as a dark-colored soil and becomes much darker when wet. The brownish-gray areas, both here and elsewhere, represent gradations between this type and the Ramona clay loam. The typical clay loam sometimes gives way to a clay in flat or swalelike positions. Some of the smaller bodies in the southern part of the survey include patches in which the soil is a loam and much more friable than the typical material. The adobe structure common to most of the type is locally absent. The deeper subsoil or substratum occasionally is quite gravelly, but gravel or stones are uncommon in the surface material. Some of the bodies lying near the coast contain quantities of marine shells.

The type is not extensive; most of it is included in two bodies lying in the northwestern part of the survey. It is mapped also in several other bodies scattered through areas of other soils of the old valley filling or coastal plain material. Most of these smaller bodies, such as the one several miles northeast of Newport and the one about 2 miles north of Seal Beach, represent the most calcareous or poorly drained parts of the old valley filling material.

The principal body of the type has a greater average elevation than the surrounding Ramona soils. Its surface is rolling or undulating, with a few steep ravine slopes, but nearly all the type is capable of tillage. Drainage is good, and the run-off in some places rapid, although injurious erosion is rare. Some of the smaller bodies farther south occupy low positions and receive seepage from higher lying land.

The principal body of this type is irrigated to a small extent. Grain and grain hay are the principal crops on this soil, and beans are grown in a small way without irrigation. Irrigation has been supplied to some parts of the type west of La Habra, where citrus fruits are grown. More extensive plantings are being made on the small body south of La Habra.

The results of mechanical analyses of samples of the soil and subsoil of a rather light textured development of this type are given in the following table:

Mechanical analyses of Montezuma clay loam adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574268	Soil	3.2	6.2	3.8	20.8	18.8	22.8	24.1
574269	Subsoil	4.2	10.8	6.4	27.4	16.4	14.8	19.8

MONTEZUMA CLAY ADOBE.

The soil of the Montezuma clay adobe consists of a dark-gray to black clay which assumes a pronounced adobe structure upon drying. The tendency of the soil to crack and granulate aids tillage operations, but the type can be cultivated only within a narrow range of moisture conditions, as it is very sticky when wet and becomes baked and flinty in dry weather. It is apparently high in organic matter and is retentive of moisture when mulched, but otherwise dries out rapidly. At depths ranging from 18 to 36 inches the soil grades rather abruptly into a lighter colored, calcareous subsoil of clay or clay loam texture. The subsoil and substrata show evidences of age, displaying modifications in structure not possessed by typical alluvial soils. Strata of gravel and other coarse material usually are absent in the subsoil.

The type includes some dark brownish gray or dark-brown variations in which the material is intermediate between the Montezuma and the Antioch or Ramona series. Minor included parts of the type as mapped have a clay loam texture; other parts merge through flattening surfaces into the recent alluvial soils. As these alluvial soils are approached the subsoil shows less distinct evidences of modification, and the type is difficult to separate from the Dublin clay adobe.

The Montezuma clay adobe is inextensive in this survey. Its principal areas lie north and south of El Modena, a small body northeast of Norwalk, others southeast and northwest of Fairview, and others in various parts of the survey.

The Montezuma clay adobe is typically undulating or rolling, but has a less diversified surface than the residual soils. Much of the type in this survey is flatter than typical, as in the body just east of El Modena, portions of which are very similar to the Dublin clay adobe. The areas southeast of Talbert are rather smooth or marked by minor irregularities such as hummocks and inclosed depressions. Some of the type occupies depressed positions which accumulate water from seepage or from the run-off, giving rise to conditions modifying both the color and chemical composition of the soil. In places injurious quantities of alkali have accumulated, which is a very unusual condition for this soil. On the whole the drainage is good.

The type is locally important where irrigation has been provided. Citrus and various other fruits have been planted and some of the orchards give good results. Portions not irrigated are used for dry-farmed grain and grain hay or for bean culture.

ANTIOCH CLAY ADOBE.

The Antioch clay adobe consists of a dark-brown or dark grayish-brown clay of pronounced adobe structure. The soil appears high in organic matter, and tillage is rendered somewhat easier, if undertaken under proper moisture conditions, by the tendency of the soil to granulate. Gravel and similar coarse materials are rare, but calcareous concretions sometimes occur. The soil gives way at depths ranging from 12 to 36 inches to lighter colored, grayish or brownish, compact subsoils of similar or slightly lighter texture The surface soil in many places is calcareous, and seams and nodules of calcareous material or very marly beds are distinguishing features of the subsoil. Samples of surface soil and subsoil of this type were collected about 1 mile southeast of Fairview for determination of the lime content. The surface soil to a depth of 30 inches was a dark-brown clay of adobe structure, somewhat darker than typical. It contained 3.27 per cent of lime in the form of calcium carbonate ($CaCO_3$). The subsoil material to a depth of 48 inches was apparently high in lime, being partially cemented and approaching a calcium carbonate hardpan. This sample contained 48.06 per cent of lime ($CaCO_3$), and doubtless represents a local area of extreme concentration of lime salts.

The type as mapped includes some dark-gray to black soils, which if more extensive might properly be classed with the Montezuma series. Included areas consist of a clay loam, with less calcareous subsoils, approaching in character the Ramona clay loam. The bodies north of Huntington Beach approach a clay loam in texture. Patches of Ramona loam and Ramona fine sandy loam are also included. These are conspicuous but too small to map separately.

With the exception of several small bodies between Wintersburg and Huntington Beach the type is confined to a large, irregular body lying between Fairview and Harper. It is not markedly different in position or surface features from the soils of the Ramona series with which it is associated. The other heavy-textured types of the old valley filling group include minor areas of the Antioch clay loam adobe.

The surface of the Antioch clay loam varies from smooth to undulating or rolling. It is fairly well drained, except in flat areas where surface water accumulates.

Practically all the type is tilled. Dry-farming methods are used almost entirely, and little attempt has been made to grow crops other than grain, grain hay, and beans. Yields are generally good, but are lower and less certain than on some of the recent alluvial soils.

The results of mechanical analyses of samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Antioch clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574252	Soil	0.1	0.7	0.6	3.2	15.0	44.6	35.9
574253	Subsoil	2.4	6.0	2.6	7.6	10.0	35.6	36.4

HANFORD SAND.

The Hanford sand typically consists of a medium to fine textured micaceous sand of light-brown or light grayish brown color. This may extend to a depth of 6 feet or more, or below a depth of 12 to 24 inches the color may be lighter brown or lighter grayish brown. The subsoil is subject to considerable variation in texture, ranging from a coarse sand to a fine sandy loam, and is sometimes stratified. The lower subsoil is of more pronounced light-grayish or grayish-brown color in the Anaheim area than in the Pasadena area to the north, the material as mapped in the latter area being uniformly light brown throughout the 6-foot section.

This type, like others of the Hanford series, is of recent alluvial origin, with distinct stratification in the underlying material. Small quantities of gravel are sometimes found through the soil on the upper parts of the alluvial fans. The type carries a small percentage of organic matter, is open and porous, and appears to retain moisture fairly well for a soil of so light texture.

The surface soil is rather uniform in much of its occurrence. The principal variations consist of differences in texture. The body south and east of Placentia is coarser than areas farther out in the valley. Some of the type lies in the bottoms of shallow stream washes and is coarser and less productive than the typical soil. In places the type merges with others so gradually that the boundaries must be placed more or less arbitrarily. Parts of the type represent severely reworked or recently deposited material, and include streaks of soil of fine sandy loam or other texture.

Most of the Hanford sand occurs as narrow areas, intermingled with other types of the same series, on the large fan-shaped plain formed by the shifting of the Santa Ana River. The most important bodies lie along this stream, especially in the northeastern part, with many others throughout the central part of the area. The elongated bodies have a northeasterly and southwesterly trend roughly paralleling the Santa Ana River channel. These strips extend more or less interruptedly from the canyon of the Santa Ana in the northeastern part of the area toward the coast, but merge with the heavier types at a considerable distance from the ocean.

Much of the Hanford sand occupies old, filled stream channels or stream-built ridges fingering out from the course of the Santa Ana River, its bodies being interrupted by deposits of heavier material. The surface is level or, along the river, gently sloping. The type may occupy or occur as ridges slightly elevated above the adjacent recent alluvial soils. In some cases areas of this soil form channels that are occupied by flood waters in times of unusual precipitation. Leveling is generally necessary for irrigation. Minor modification in the surface configuration has resulted from wind action, but the heaping or drifting of the soil material is only local and is not severe. The surface drainage usually is good; in places it is excessive. Subdrainage is well developed, but some of the flatter, lower parts have a high water table. Here slight accumulations of alkali occur.

The Hanford sand is an important type, but it is not so productive as the heavier types of the series nor so extensive as the Hanford fine sandy loam. About 75 per cent of the type is under cultivation, usually for fruit crops, grain, sugar beets, or alfalfa. Some areas adjacent to the Santa Ana River and a strip south of Placentia are uncultivated. Oranges are the most important of the intensive crops. Southwest of Santa Ana sugar beets are grown. Other crops grown are peaches, walnuts, apricots, lemons, and grapes. Dry-farmed grain constitutes a temporary use of this soil farther out in the valley, the other crops usually being irrigated. This type is generally farmed in small holdings or forms small parts of farms. Owing to its light texture it can be tilled in all seasons, ordinary precipitation having little effect on cultural operations.

Crop yields depend largely upon irrigation. Dry-farmed areas give lower yields than are obtained on heavier types. Barnyard manure, green manures, and commercial fertilizers are used where fruit crops are grown, little or no fertilizer being applied where dry farming is practiced. The price of land varies greatly and depends mainly upon location and improvements.

The Hanford sand is materially improved by incorporating stable manure and other organic matter in the soil.

Hanford sand, coarse phase.—The Hanford sand, coarse phase, typically consists of a brown, light-brown, or light grayish brown, micaceous, gritty, coarse sand, carrying enough material of the finer grades to influence the water-holding capacity and crop value of the soil. The phase varies greatly in depth and character of subsoil. It is sometimes underlain at about 12 inches by strata of heavier texture. More often the subsoil is very coarse, but heavier layers usually lie at a depth of less than 6 feet. The phase for the most part is less retentive of moisture than the typical Hanford sand, and the coarsest areas are poorly adapted to many crops.

This phase of the Hanford sand is represented by several small bodies occurring in the region between Garden Grove and Orange. It merges with other soils making up the large alluvial fan of the Santa Ana River, but usually occupies the crests of slight, stream-built ridges. Some bodies are broken by other soils, such as the typical Hanford sand. Drainage usually is good, as a rule being more thorough and rapid than that of surrounding types. The water table is prevailingly deep, except during the rainy season.

Practically all the phase is utilized, largely for the production of irrigated orchard crops. Yields average lower than on the typical Hanford sand. Most of the phase seems to be benefited by the addition of organic matter and fertilizers.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this phase:

Mechanical analyses of Hanford sand, coarse phase.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574220	Soil	15.5	28.7	11.0	22.2	9.8	9.6	3.3
574221	Subsoil	24.6	31.8	11.8	20.2	5.2	4.6	2.0

HANFORD SANDY LOAM.

The Hanford sandy loam typically consists of a light-brown, brown, or light grayish brown, medium to rather fine textured, micaceous sandy loam which may vary little in texture to a depth of 6 feet or more, though at 12 to 24 inches the subsoil often is slightly lighter colored than the surface soil. Both soil and subsoil usually are friable and porous, but the subsoil often shows considerable stratification, and like that of other light-textured recent alluvial soils may be made up of strata of variable texture. The soil contains only a moderate percentage of organic matter and is only fairly retentive of moisture, crops often suffering from drought where irrigation is delayed or is not practiced. Plant roots easily penetrate both the soil and subsoil.

The soil shows some variation from the typical in origin, color, texture, organic-matter content, drainage, and structure, owing to the great extent of the type and the manner in which it merges with other soils. While most of the bodies are typical in color, moisture conditions cause some variation. When moist the soil generally has a more brownish appearance, but it becomes light grayish brown or even light gray in some areas upon drying. The lighter gray variations closely approach the gray soils of the related Tujunga series,

which have a similar origin but are not typically developed in this survey. The type averages a lighter grayish brown in this area than in most other regions in the State in which it has been recognized. Certain areas farther out in the valley have greater accumulations of organic matter and are darker in color than typical. These areas often have rather poor subdrainage. The type as mapped includes some material derived at least in part from sedimentary rocks.

The extensive bodies of this type merge with surrounding soils, and small areas are included which range in texture from a loamy sand or fine sand to a fine sandy loam. In some of the minor valleys in the foothills and in the western extremity of the body extending westward from Irvine the material approaches a sand in texture. These lighter-textured variations have a more pronounced grayish-brown color and are lower in organic matter than the typical soil. Gravelly areas are encountered along the streams northeast of Myford, in some of the narrow alluvial valleys lying in the foothills, and southwest of Orange. The gravel usually is insufficient to influence agriculture or materially alter the soil and subsoil structure. The type grades by changes in subsoil and color into the adjacent and related soils of the Chino series, and near the latter the subsoil may be somewhat modified, slightly calcareous, and mottled. Variations are encountered in which the surface soil is shallow and the subsoil heavier than the surface material, resulting from a shallow overwash of Hanford sandy loam material over heavier soil. A shallow variation is encountered in places in narrow valleys or at the base of hills, in which the type is sometimes underlain at various depths by residual soil.

The more extensive and uniform areas of the Hanford sandy loam are distributed over the large fan-shaped plain built up by the Santa Ana River. The bodies usually are long and narrow, and roughly parallel the course of the main river channels. They give way to heavier textured, more poorly drained soils midway toward the ocean. The type also occurs to a small extent along the flood plain of the San Gabriel River. The most important areas are mapped in the vicinities of Anaheim, Garden Grove, Westminster, Cypress, Belflower, and Norwalk. Other areas lie along the foothills in the eastern part of the area, mainly in the vicinity of Irvine. The type here occurs in stream bottoms and on low, recent terraces and alluvial fans of smooth or gently sloping topography.

The surface of the type is gently sloping. It usually is smooth and well adapted to irrigation. Portions of the type lie at a slightly higher elevation than the adjacent heavier and more compact soils, and in some instances at slightly lower elevations than the Hanford sand. Some of the surface is faintly ridged, as a result of deposition of material across the surface of the fan by minor distributing

streams. The Hanford sandy loam is generally well drained in both soil and subsoil, but some areas in the west-central part of the survey, near soils of the Chino series, have a high water table. Accumulations of alkali frequently occur in such places. A small part of the area about 3 miles west of Irvine also is affected by alkali, which occurs mainly in the subsoil. Throughout most of this type an underground supply of water exists, and it is from this supply that a great part of the irrigation water is obtained.

The Hanford sandy loam is a very important soil in the agriculture of the Anaheim area. Practically all the type is in use, much of it producing valuable field and orchard crops. Sugar beets are important in areas having a high water table. Yields of all irrigated and intensively cultivated crops are good. Beans, grain, and grain hay are dry-farmed with moderate yields. In the eastern part of the survey beans are the most important crop in acreage; oranges, lemons, and walnuts are grown locally north of Irvine. Citrus and deciduous fruits and truck crops are fertilized, commercial fertilizers as well as cover crops and barnyard manure being used.

The price of land of this type ranges from about $100 an acre for some of the unimproved lighter-textured areas and more remote areas to very much higher prices for the citrus-fruit or walnut lands. The better bean land also has a high value. Sugar-beet and alfalfa land ranges from $250 an acre upward.

This soil requires liberal irrigation and the addition of organic matter for best results with orchard crops.

HANFORD FINE SANDY LOAM.

The Hanford fine sandy loam as mapped in this survey typically consists of a brown to light grayish brown, micaceous, friable fine sandy loam, which may extend to 72 inches or more in depth, but is often underlain below about 12 inches by a subsoil of variable texture, ranging from a sand to a light loam. Frequently the only distinction between the soil and subsoil is in the color of the latter, which typically is a lighter brown, but the subsoil is often a little more compact than the surface soil. The type shows the stratification typical of recent alluvial deposits. It generally possesses a fair to moderate percentage of organic matter and is absorptive and retentive of moisture. The texture in the Anaheim area averages somewhat heavier than in the adjoining Pasadena area.

The Hanford fine sandy loam is extensive and varies considerably in different parts. It is periodically subject to overflow in many places and may be modified at such times by deposits of coarser or finer alluvial materials. The color is darker than typical, the texture usually is heavier, the organic-matter content greater, and the difference between the soil and subsoil more distinct along the

contact with soils of the Chino series. Some true Chino material may be included in such places. In the zone of gradation between the Hanford and the Chino soils the surface soil is often typical of the Hanford, while the deeper subsoil, being more compact, slightly mottled with grayish, and carrying a few calcareous concretions, more closely resembles the Chino subsoil. Some of the type in the Talbert region and elsewhere near the ocean has well-defined layers of Peat in the subsoil. Much of the soil on the upper parts of the large fan built up by the Santa Ana River is lighter colored and of lighter texture than typical. Such localities have a grayish appearance under dry field conditions and resemble areas of the related lighter-colored Tujunga soils. Bodies of the type often include coarse sandy or slightly gravelly strips along streams that have a vigorous flow. Typical bodies of the Hanford fine sandy loam generally merge with other types with indistinct boundaries, and frequently small areas of soil of other textures are included. Concentrations of alkali salts affect much of the type.

The Hanford fine sandy loam is the most extensive type of the area and occupies important parts of the broad alluvial fan that spreads toward the coast from the mouth of the Santa Ana Canyon. It also forms a part of the overflow plain of the San Gabriel River. It occurs in numerous elongated and narrow bodies as well as several extensive areas such as those along the Santa Ana River and east and north of Los Alamitos. It generally gives way to other soils at considerable distances from the ocean, except on the flood plains of the Santa Ana and San Gabriel Rivers.

The Hanford fine sandy loam has the typical topography of the more gently sloping alluvial fans. Its broad, uniform surface is very favorable to irrigation. Some irregularities occur, such as slight erosions or stream-built ridges.

This type is traversed by the large rivers of the survey as well as by minor creeks. On the higher parts of the alluvial fans both the soil and subsoil are well drained. In the lower areas the type has a high water table, which in the wet season lies from a few inches to a few feet below the surface. Important bodies have a permanent water table at less than 6 feet from the surface. Accumulations of alkali occur in the lower areas. Parts of the type are subject to periodic overflow; other portions are inundated very rarely and only at times of exceptional floods. Locally along the larger streams the soil is partly covered by water for a part of the wet season. Water stands in some of the minor depressions for short periods, and the flood waters are sometimes so slow to drain away that removal by pumping is resorted to. Drainage in the lower part of the type is improved to some extent by artificial means, mainly in the western and southwestern parts of the survey.

The Hanford fine sandy loam is an important soil agriculturally, and practically all of it is in use. Many different crops are grown. In the better drained areas oranges, lemons, peaches, walnuts, apricots, apples, grapes, grapefruit, and a number of other crops thrive under irrigation. Dry-farmed grain and grain hay also are grown, and alfalfa produces heavily on the better drained land. Alfalfa is produced also in some areas with deficient drainage, but the soil is less well adapted to the crop under such conditions. Sugar beets and truck crops are grown largely in the poorly drained areas. The soil is easily worked at any season of the year in all parts not subject to poor drainage conditions. Where the drainage is poor it frequently is late in the season before the land can be prepared for crops.

A plentiful supply of underground water usually is available for irrigation, and the water now applied is obtained largely by pumping from this source. The yields of the irrigated crops are usually good. It is considered necessary to summer fallow grain land in alternate years, in order to obtain fair yields. The type seems better adapted for intensive cultivation than for dry farming.

Stable manure, green manures, and commercial fertilizers are applied in growing fruit and truck crops. A typical sample of the subsoil of this type was found by laboratory examination to contain 1.63 per cent of lime.

The Hanford fine sandy loam is one of the most highly prized soils of the area. The price of the land ranges from several hundred dollars to $1,000 or more an acre, depending mainly on its development and suitability for citrus fruits or other special crops. In the lighter-textured areas of the type the supply of organic matter is sometimes deficient. In such cases the incorporation of barnyard manure and the plowing under of cover crops and green manures are very beneficial.

The results of mechanical analyses of samples of soil and subsoil of this type are given in the table below. In these samples the surface soil is slightly heavier than the average for the type, approaching a loam in texture.

Mechanical analyses of Hanford fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574224	Soil	1.2	3.4	3.2	16.6	25.4	43.6	6.6
574225	Subsoil	1.8	6.4	4.3	21.7	23.0	35.4	7.4

HANFORD LOAM.

The Hanford loam typically is a brown, friable, micaceous loam, which may extend to a depth of 6 feet or more or may be underlain below about 12 inches by strata ranging in texture from sand to silt loam. The subsoil usually is lighter in color than the surface soil. The soil is more compact, contains more organic matter, and is more retentive of moisture than the lighter types of the series. As mapped in this survey it is somewhat variable. In many places it occupies slight depressions, which receive drainage from adjacent soil types. In the central part of the area, where the type adjoins lighter soils of the series, it generally contains more coarse material than farther out in the valley, where it grades into soils of more silty texture. The color averages darker than that of the lighter textured Hanford soils. Much of the type approaches the dark-gray or gray color of the Chino series, and the soil and subsoil are more frequently calcareous than is typical of Hanford material. Calcium carbonate determinations of samples of this type indicate a lime content in the soil and subsoil of 1.11 per cent and 0.86 per cent, respectively. The soil frequently is dark brown over small areas where the content of organic matter is relatively high, and a dark-gray, mottled, calcareous subsoil often accompanies this condition. This type is more silty and smooth textured in this area than in the Pasadena area and is of more pronuounced grayish color.

The Hanford loam occurs in the central, western, and southern parts of the survey. The principal areas lie southwest of Anaheim, at Garden Grove, along the lower Santa Ana River, southwest of Los Alamitos, in the vicinities of Belflower and Artesia and west of Gloryetta.

The topography of the Hanford loam is similar to that of the other types of the series, i. e., prevailingly gently sloping or level, some of the small, narrow bodies occupying slight depressions. West of Anaheim and at Garden Grove the type is fairly well drained; in the western part of the survey it generally has a high water table and accumulations of alkali occur. Along the larger streams the type is subject to overflow and the run-off from higher soils accumulates in depressed areas. East of Huntington Beach and along the lower San Gabriel Valley water sometimes stands on the surface until removed by pumping.

The Hanford loam is not so extensive as the Hanford fine sandy loam or sandy loam. Most of it is cultivated. Many different crops are grown. The better-drained parts support orchards of oranges, lemons, walnuts, and deciduous fruits, and a considerable acreage of alfalfa, while the more poorly drained areas and those subject to alkali accumulation are used for the production of sugar beets and

truck crops, with some grain and alfalfa. Practically all crops, except grain, are irrigated, water in most cases being pumped from the underground supply.

The soil is friable under ordinary moisture conditions and is easily worked, except during the wet season. Average yields are good, as on most of the irrigated soils of medium texture. Under dry farming heavier yields are obtained on the lighter types of the series. Except that less manure is used, fertilization of this soil does not differ from that of the lighter types of the series.

The price of land of the Hanford loam is about the same as that of the Hanford fine sandy loam.

YOLO FINE SANDY LOAM.

The Yolo fine sandy loam consists of a brown or light-brown, friable fine sandy loam ranging from 1 to 6 feet or more in depth. Where the fine sandy loam material is less than 6 feet deep it is underlain by strata of varying texture, which are sometimes slightly more compact than the surface soil and usually somewhat lighter colored. The subsoil strata extend to undetermined depths. This soil typically is less micaceous than the Hanford fine sandy loam. It contains moderate to small quantities of organic matter and, having an open, porous nature, is not very retentive of moisture. Heavier variations, or those underlain by material of heavier texture, however, are exceptions to the rule.

This type is subject to some variation in both texture and depth. The bodies mapped include small areas that are sandier and some that are heavier than the typical soil. These variations represent included patches of other types of the series. Near the hills, in stream-valley positions, or along the boundaries of coarser types the soil carries gravel and small bowlders. This is particularly noticeable over much of the body lying along the upper part of Santiago Creek, where coarser and leachy soils prevail. A variation in depth occurs in the upper part of the area east of Myford, which consists of a shallow overwash over heavier types of the Yolo series. The type near Santa Ana and Orange is much like the Hanford fine sandy loam and the soil boundaries locally are somewhat arbitrary. The subsoil is modified in places by weathering, and is not typical, resembling the subsoil of the Ramona or other series derived from old valley-filling material.

The Yolo fine sandy loam is inextensive. It is mapped in bodies of small or medium size in the northern, eastern, and southeastern parts of the area. The principal bodies lie near Santa Ana and Orange, east of Myford, north and northeast of El Modena, and in the vicinities of Olinda, Placentia, La Habra, and Fullerton. Small bodies lie northeast of Irvine and south of El Toro.

The Yolo fine sandy loam possesses a gently sloping topography. The surface is generally smooth and favorable to irrigation, although cut in places by shallow channels that carry water in times of overflow. Some areas, as those along Santiago Creek, are more dissected than the typical, and have been modified more by overflow. Both soil and subsoil are generally well drained.

This is an important soil, considering its rather small extent. Practically all of it is tilled. Orchards of citrus fruits and English walnuts are important, and some of the better citrus and walnut groves of the Anaheim area are located on this soil. Smaller acreages are in grain and beans. Untilled areas are used for pasture. In general, crop yields are good. Irrigation is considered necessary for orchard crops and for maximum yields of most field crops. Fertilizers are applied and barnyard manure and green manures are used where specialized crops are produced. The type apparently is in need of organic matter.

As encountered in this survey, the type contains a higher percentage of lime than is usual for this type of soil, a typical sample of the surface soil analyzing 1.86 per cent, and a sample of the subsoil 2.36 per cent, of calcium carbonate.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Yolo fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574230	Soil	0.0	0.8	1.4	39.6	24.8	25.1	8.5
574231	Subsoil	.1	1.4	1.6	27.6	20.0	31.8	17.7

YOLO LOAM.

The soil of the Yolo loam is a brown, fairly friable loam, in places extending to a depth of 6 feet or more, and in others underlain at 12 to 24 inches by strata of heavy sandy loam, loam, or silt loam texture. The color of the subsoil or the deeper part of the section usually is lighter brown than that of the surface material. The surface soil is somewhat sticky when wet, but is friable under favorable moisture conditions and forms a good mulch. The subsoil is easily penetrated by roots. The Yolo loam is absorptive and retentive of moisture. Typically the soil contains a moderate percentage of organic matter, and both soil and subsoil are well supplied with lime. Analyses of typical samples of the soil and subsoil showed 0.42 per cent of calcium carbonate in the surface soil and 2.04 per cent in the subsoil. The type usually is nonmicaceous, but east of Myford and in the

vicinities of Tustin and Santa Ana varying quantities of mica are present, the material in this respect resembling that of the Hanford series. The color of this type varies somewhat, ranging from a light brown near the lighter textured types to dark brown where the type gives way to heavier soils of the series. The lighter colored material is less compact and contains less organic matter than the darker variations. In some cases the soil is slightly reddish brown. The soil varies in depth, which shows some relation to location. On steep slopes, in narrow alluvial valleys, or near old valley filling soils it may be less than 6 feet deep, resting upon substrata of residual or unconsolidated old valley filling material. Variations in texture are common, the soil becoming lighter as lighter textured types are approached and heavier in regions of heavier soils. Small bodies of other types of the series are included with this type. Some gravel may occur in both the soil and subsoil, as near El Toro, but usually this has little bearing on the value of the land for agriculture.

The Yolo loam occurs througout the northern, eastern, and southeastern parts of the survey. Its bodies vary in size from a few acres to several square miles. The largest areas lie near Fullerton and Santa Ana.

The surface is generally gently sloping, moderately smooth, and well suited to irrigation. The type ususally is well drained, but in places the subdrainage is poor and accumulations of alkali occur, as north of Buena Park and west of Irvine. Some parts of the type are marked by shallow, discontinuous drainage or overflow channels.

The Yolo loam is one of the most important soils of the area, and practically all of it is tilled. Grain and beans, produced without irrigation, are important crops, but the chief use of the type is for the production of walnuts, oranges, lemons, deciduous fruits, and alfalfa. The orchards are irrigated, and produce heavily. Where properly cultivated and fallowed in alternate years, the Yolo loam is well adapted to dry farming, although the average yields under this system are lower than on some of the heavier soils. Stable manure, green manure, and commercial fertilizers are applied in the orchards.

The price of this land varies widely, and depends on many factors, mainly location, with reference to cities and towns, and the character of the improvements. The average price is high, and the soil is largely held in small acreages.

YOLO CLAY LOAM.

The surface soil of the Yolo clay loam consists of a brown or dark-brown medium to heavy clay loam from 12 to 24 inches in depth. Typically, this soil is darker in color than the Yolo loam, and ap-

parently it contains a higher percentage of organic matter. The soil is sometimes compact, but is rather friable and retentive of moisture where cultivated. The subsoil often is a clay loam, but ranges from a loam to a clay, or it may consist of alternating strata of material of variable texture. The subsoil typically has a lighter brown color than the surface soil. Local strata of gravelly or sandy material sometimes are encountered in the subsoil, but are less pronounced than in the lighter textured types of the series. Concentrations of calcareous material sometimes occur in the subsoil, but this condition is not considered typical. A sample of the subsoil of this type analyzed 3 per cent of lime ($CaCO_3$). The soil column to a depth of 6 feet or more usually is permeable to roots and water.

The type is rather uniform over its more extensive bodies, but there occur some departures from the typical in color, texture, structure, depth of soil, and organic-matter content. The usual brown color frequently gives way to a lighter brown in marginal areas where the type grades into the lighter textured types of the series, and to darker brown variations, sometimes approaching dark gray, where the type adjoins soils of the Dublin series. A darker color is sometimes developed in swales or depressions, and here the soil is also of heavier texture and usually higher in organic matter. Some of the type north of Wanda, with rather good slope and drainage, is dark colored and much like the soils of the Dublin series. Very frequently lower spots, as well as areas grading into adobe types, crack upon drying and assume a typical adobe structure. The type may be 6 feet or more in depth in some of the narrow alluvial valleys, the depth decreasing as the residual hill soils are approached. Near the residual soils the underlying material may be residual in character. Several feet of the typical friable soil of this type sometimes overlies older, weathered, compact deposits of slightly reddish brown color and adobelike structure. The color of the subsoil has been affected by poor drainage in some small areas adjacent to heavier, more poorly drained types, and it sometimes resembles the material of the Chino series. The subsoil also is more calcareous in areas of retarded drainage, and the surface soil in such places may have a more compact structure. Where the type merges with types of lighter or heavier texture the soil may vary to a loam or a clay. Shallow overwashes of lighter textured material occur locally, often having a lighter color than the typical Yolo clay loam. The type in the southeastern part of the survey is relatively free from gravel, except in the immediate vicinity of gravelly types, and there is seldom sufficient gravel present to affect its use for agriculture. In the bodies northeast of Wanda and north of Villa Park there is enough gravel in places to affect tillage operations and the water-holding capacity of the type.

The Yolo clay loam occurs through the northern, eastern, and southeastern parts of the area, the most extensive bodies lying south of Santa Ana and Tustin, in the vicinity of Irvine, and south of La Mirada. Many smaller bodies lie in narrow valleys in the upland and foothill regions. The boundaries of the larger bodies usually are less definite than those of the stream-valley areas.

The surface is generally smooth and gently sloping. Some parts of areas of older deposition have a gently undulating topography, but all parts of the type are well adapted to irrigation. Streams and shallow drainage ways traverse the type and usually give good drainage except in low areas or in regions of intermittent overflow. The large body extending eastward from New Delhi to Como is in part poorly drained and contains injurious accumulations of alkali. The Yolo clay loam has larger areas subject to poor drainage than the Yolo loam.

The Yolo clay loam is important agriculturally. It is one of the best dry-farming soils of the area and much of it has reached a high state of development under irrigation. Practically all the type except the poorly drained and alkali areas is utilized for more intensive crops than hay and grain. Walnuts, oranges, lemons, some deciduous fruits, beans, sugar beets, alfalfa, and grain are the principal crops. The average yields compare favorably with those obtained on the Yolo loam. The extensive areas in the southeastern parts of the survey produce good yields of beans without irrigation. The soil seems well adapted to this crop. Fruits, nuts, alfalfa, and sugar beets are largely irrigated, some of the water being pumped from an underground source and some diverted from streams. Sugar beets are often grown in the more poorly drained localities and good yields are obtained where too much alkali is not present. Barnyard manure, green manures, and commercial fertilizer are applied, and cover crops are grown in orchards and to some extent in the walnut groves.

The average results of mechanical analyses of typical samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Yolo clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574232, 574274.....	Soil.....	0.6	1.5	1.4	20.9	22.8	29.3	23.4
574233, 574275.....	Subsoil.....	1.5	3.9	2.8	30.2	17.8	25.2	18.4

YOLO CLAY ADOBE.

The Yolo clay adobe is a brown to dark-brown, heavy, compact, and sticky clay of adobe structure, extending to a depth of 12 to 24

inches. The color is darker and the organic-matter content higher than in any other type of the Yolo series. The surface soil cracks and is very hard and flinty when dry and uncultivated, but is moderately friable when it contains the right amount of moisture. It can not be handled successfully when wet. When given proper cultivation its power to retain moisture is high. The surface soil is underlain to a depth of 72 inches or more by a brown clay loam or clay subsoil, sometimes calcareous, and in local areas slightly mottled. A sample of the subsoil analyzed 1.13 per cent of lime in the form of calcium carbonate. Some of the subsoil of this type resembles the material underlying some of the old valley filling soils. In places the soil is slightly lighter in color and of less pronounced adobe structure than typical, and it merges with the Dublin clay adobe through darker variations. Thin overwashes of sandy material streak the surface as minor tongues from higher lying lighter structured soils.

The Yolo clay adobe occurs principally in several large areas northwest of Irvine and east of Paularino, and smaller areas lie south and southwest of Irvine, near the San Joaquin Hills.

The surface is smooth to gently sloping or slightly undulating, and well adapted to irrigation. Practically all the type is well drained by means of intermittent drainage ways, which are sometimes entrenched. The area east of Paularino, and some other parts, are comparatively flat. In these the drainage is stagnated and alkali has accumulated.

This type is less extensive and less important than the clay loam member of the series. The greater part of it is utilized for the production of beans, sugar beets, and grain, beans occupying the greatest acreage. A small part of the type having poor drainage is used for pasturage. Beans and grain are produced without and sugar beets with irrigation. The Yolo clay adobe is a good soil for dry farming, as it conserves moisture well. Crop yields average about the same as on the Yolo clay loam.

The price of land of this type is about the same as of the Yolo clay loam.

The following table gives the results of mechanical analyses of typical soil and subsoil samples of this type:

Mechanical analyses of Yolo clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574260	Soil	0.2	2.4	2.2	15.0	13.8	32.5	33.9
574261	Subsoil	1.6	5.4	3.4	17.0	14.0	29.1	29.4

DUBLIN CLAY ADOBE.

The Dublin clay adobe consists of a dark-gray to black, sticky, heavy, compact clay of adobe structure, underlain usually at 12 to 36 inches by a brownish or grayish heavy clay loam or clay which extends to a depth of 6 feet or more. A high organic-matter content is indicated by the dark color of the surface soil. Seams or concretions of limy material occur in places in the subsoil, though it is not typically calcareous. The soil is retentive of moisture. Under proper moisture conditions it is fairly friable for a soil of so heavy texture, but it bakes hard and cracks when dry and uncultivated. Plant roots penetrate the soil and subsoil without difficulty where the type is well drained.

Some of the Dublin clay adobe areas, as those northwest of Irvine, are puddled, refractory, and of less favorable structure than typical. Some dark brownish gray soil is included which approaches the color of the darkest parts of the Yolo clay adobe. Small quantities of gravel are locally present. The subsoil occasionally is compact and sufficiently weathered to resemble that of some of the old valley filling soils. Where poorly drained it frequently is mottled or of a grayish color and contains more concentrations of lime.

The type is inextensive. It occurs in two bodies northwest of Wanda and northwest of Irvine, and in smaller areas southeast of Wintersburg and southeast of Paularino.

The surface of the Dublin clay adobe is smooth or gently sloping to nearly flat, the type sometimes occupying rather depressed areas. The drainage northwest of Wanda is generally good, but over the greater part of the area northwest of Irvine and elsewhere it is less satisfactory. The water table lies within a few feet of the surface in the poorly drained areas. These also may be overflowed during the wet season. The low areas usually lie within regions in which artificial drainage systems have been installed. The poorly drained areas contain accumulations of alkali.

The body of the type northwest of Wanda produces citrus fruits, and is the most valuable part of the type. Beans, sugar beets, and grain are the most important crops on the rest of the type. Small areas containing alkali are used for pasture. The average crop yields depend largely upon position and drainage, being good for the better drained parts of the type. The intensive crops are fertilized. This is a difficult soil to handle, and for best results the organic-matter content should be increased and the physical condition improved in other ways.

The results of mechanical analyses of typical samples of the soil and subsoil are given in the following table:

Mechanical analyses of Dublin clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574240	Soil	0.8	1.9	1.0	5.4	15.0	34.3	41.6
574241	Subsoil	2.0	3.8	2.7	10.6	19.8	32.2	29.2

CHINO SILT LOAM.

The Chino silt loam in this survey is somewhat browner than the typical Chino material and approaches in places the character of the Hanford silt loam. It consists of a brownish-gray, micaceous silt loam which either extends to a depth of 72 inches or is underlain below 12 inches by strata of slightly lighter color and variable texture. The soil generally contains moderate quantities of organic matter and is retentive of moisture.

A somewhat mottled subsoil, due to poor drainage, often underlies the type, especially in the western part of the survey. Concentrations of calcareous material occur in the subsoil, and the surface soil may be calcareous in some places. The lime content of a subsoil sample representing material from a depth of 18 to a depth of 60 inches, collected one-half mile east and 2½ miles south of the Llewellyn School, contained 2.75 per cent of lime in the form of calcium carbonate.

Several fair-sized bodies of the Chino silt loam are around Greenville, southeast of Talbert, and in the vicinity of Los Alamitos, and smaller areas lie in the central and western parts of the survey. It occupies the almost level, rather poorly drained lower extensions of broad alluvial fans. The drainage is deficient, and the type in places is partly inundated during a part of the wet season. Drainage in the western and southern parts of the survey has been improved to some extent by artificial means. All the large areas except that around Greenville contain accumulations of alkali.

About 75 per cent of the Chino silt loam is farmed. The chief crops grown are sugar beets, grain, and alfalfa. The average yields of these crops where not injured by alkali is good. Little fertilizer is used, although some stable manure is applied. Near Garden Grove fruit crops are grown and receive the fertilizer treatment customary for these crops.

Land of this type is held for about the same price as the Hanford loam in the same general section.

The following table gives the results of mechanical analyses of typical soil and subsoil samples:

Mechanical analyses of Chino silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574270	Soil	0.2	0.3	0.3	1.6	13.2	61.3	23.5
574271	Subsoil	.0	.2	.1	1.2	15.5	61.2	21.9

CHINO SILTY CLAY LOAM.

The surface soil of the Chino silty clay loam is a dark-gray, micaceous, friable silty clay loam, 12 to 16 inches or more in depth. It contains a moderate to high percentage of organic matter and is retentive of moisture. The subsoil to a depth of 6 feet or more usually is a gray, mottled loam, silty clay loam, or silty clay. It often has a high lime content, the lime being present in the form of seams, concretions, or other concentrations, or occurring as marly material. Laboratory examinations of samples of the soil and subsoil of this type taken near the Springdale School showed them to contain 7.81 per cent and 31.54 per cent of calcium carbonate, respectively. The subsoil is lighter in color than the surface soil and has been modified considerably by poor drainage.

The type is more uniform than the Chino clay loam, but includes some variations, due in part to poor drainage. Where it adjoins lighter textured soils, especially those of the Hanford series, the soil frequently is brownish or brownish gray and often more gritty than typical. Some parts of the type are more sandy than typical. Areas adjacent to bodies of Muck and Peat are of relatively dark color, and the type as mapped contains areas of Muck and Peat too small to be mapped separately. The subsoil may vary greatly within the 6-foot section in color and texture, and the characteristic calcareous material is sometimes confined to a single stratum several inches in thickness.

The Chino silty clay loam occurs in larger bodies than the Chino clay loam. It is developed in the southern and southwestern parts of the survey, the largest areas lying south of Los Alamitos, east of Smeltzer, and in the vicinity of the Springdale School. The surface of most of the type is smooth, very gently sloping or nearly flat, and is favorable for irrigation. Some minor depressions and hummocks mark the surface. As in most of the types of the Chino series, the water table naturally lies near the surface, but is largely controlled by drainage canals. Springs and seepage areas occur in many places,

and flowing wells are common. The type is, in part, subject to overflow and flood water disappears slowly. Practically all the type is more or less affected by concentrations of alkali.

The Chino silty clay loam is fairly extensive. The greater part is used for the production of sugar beets or grain. Small acreages of beans are grown in the better drained areas. Crop yields vary greatly and depend largely upon alkali conditions. Areas containing much alkali are untilled and are used for pasture. Sugar beets, being resistant to alkali, seem to do better on this soil than other crops, but even beets give low yields where the salts are strongly concentrated. The price of land of the Chino silty clay loam ranges up to several hundred dollars an acre in the better drained parts of the type.

The results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Chino silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574209	Soil	0.2	0.3	0.4	5.4	8.8	61.4	23.9
574210	Subsoil	.3	.6	.6	5.0	4.4	60.1	29.0

CHINO CLAY LOAM.

The Chino clay loam typically is a gray to dark-gray or brownish-gray, micaceous clay loam, resting at a depth of about 24 inches or less upon a mottled grayish subsoil of variable texture which extends to a depth of more than 6 feet. The typical Chino clay loam has been modified physically and chemically by conditions of poor drainage, the changes being more apparent in the subsoil. The subsoil typically is calcareous and contains nodules and seams of calcareous material. The surface soil also generally contains more or less lime. The lime content in the subsoil is excessive in places, giving rise to a marly condition. Samples carefully collected to represent the average or typical condition analyzed 5.09 and 26.90 per cent lime ($CaCO_3$) for the soil and subsoil, respectively. This high content is due to the leaching of the lime from adjacent higher lying soils, and their localization in areas of arrested drainage. It possibly represents an extreme condition for this soil type, but the average content of lime in both soil and subsoil is normally high. Ordinarily the soil contains a fair amount of organic matter, is retentive of moisture, and friable.

The Chino clay loam is variable. The color is subject to wide variation, and ranges from brown near the Hanford types to dark gray or black near types of the Dublin or Chino series or areas of

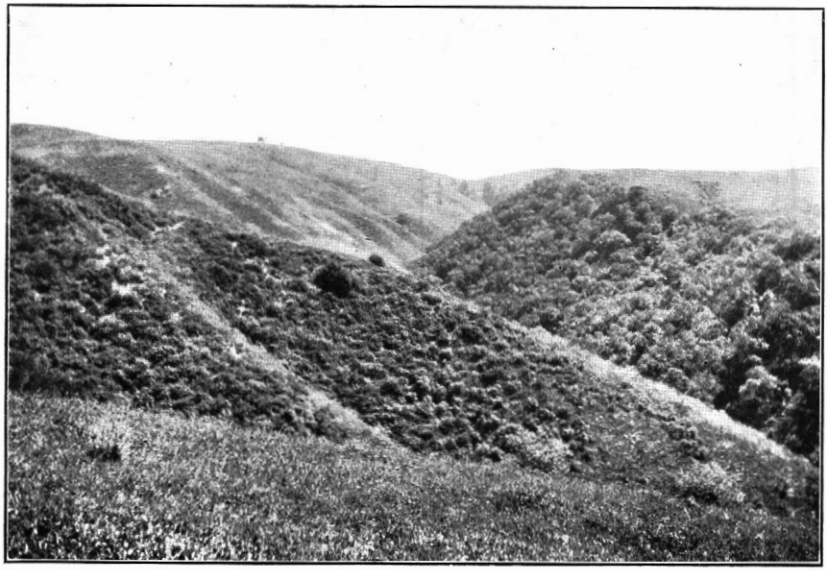

FIG. 1.—CHARACTERISTIC TOPOGRAPHY AND NATIVE VEGETATION ON ROUGH BROKEN AND STONY LAND, NORTH OF LA HABRA.

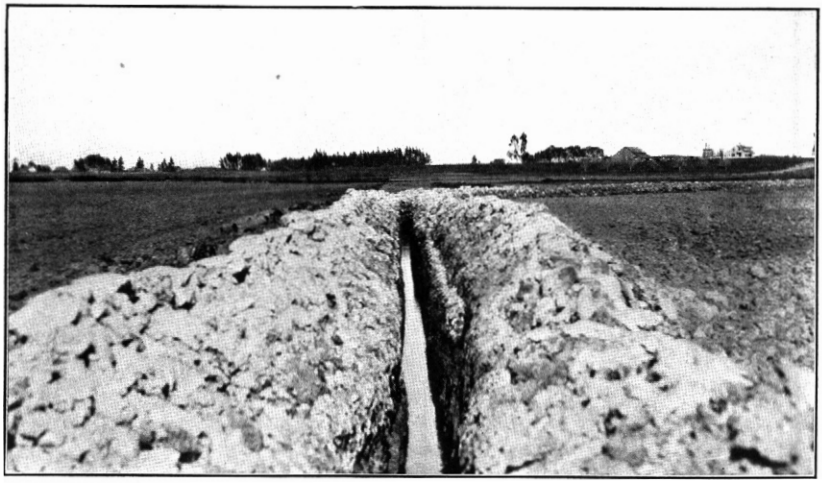

Photo from Univ. of Cal.

FIG. 2.—DRAINAGE DITCH READY TO RECEIVE TILE ON CHINO SILTY CLAY LOAM, NORTH OF HUNTINGTON BEACH.

Muck and Peat, of which latter it includes small areas. The texture varies somewhat with the color, being more gritty and containing less organic matter in the browner areas than in the typcial darker-colored areas. In some places the subsoil is similar to that of the Hanford series. Layers of peaty material of varying thickness may occur in the subsoil. Some parts of the type nearest the ocean originally were within the zone of tidal deposition, and subsequently were covered by stream deposits. The subsoils in such cases are comparatively heavy, gray in color, frequently very silty, usually compact, and high in content of soluble salts. Some areas lying adjacent to types of the Hanford series consist of an overwash of Hanford material, usually 2 to 4 feet deep, resting upon a gray, poorly drained subsoil. Small bodies such as the one near La Mirada are darkened, modified, flattened areas of material similar to the higher soils usually mapped as the Ramona series. Some of the included material of light texture constitutes a fairly well defined light-textured soil which, because of its limited extent, can not satisfactorily be separated. If of greater extent it would be recognized as another type of the Chino series. It has a gray or brownish-gray to dark-gray surface soil underlain by the mottled variable subsoil characteristic of the series. This variation generally carries considerable organic matter, and is often very micaceous. Some bodies near the ocean or adjoining areas of Tidal marsh contain shells.

The Chino clay loam is largely confined to the poorly drained sections in the southern and southwestern parts of the survey. The largest bodies lie in the vicinities of Bolsa, Westminster, and Alamitos Bay, and smaller areas south of Santa Ana, east of Huntington Beach, and near La Mirada. Boundaries are generally well marked, especially where the type adjoins soils of the Hanford series. The smaller areas often are partly surrounded by soils of the Hanford series and occupy relatively lower positions. The lighter-textured variations of the type occur mainly in the vicinity of Bolsa, south and west of the Springdale School, and near Westminster.

The surface is gently sloping, smooth, or nearly flat, and is well adapted to irrigation. The soil is typically poorly drained and has a high water table. Portions are occasionally overflowed. Practically all the type contains varying quantities of alkali. Most of it lies in the artesian belt. It is drained by extensive artificial drainage systems.

Most of the Chino clay loam is tilled. Sugar beets constitute by far the most extensive crop, but grain, beans, and truck crops are grown to some extent. Uncultivated areas are used for pasture, as crop yields vary considerably and depend largely upon the quantity of alkali present.

The price of this land varies with its productive capacity and location. Where good crops are possible the land is held at several hundred dollars an acre.

The results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Chino clay loam

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574262	Soil	1.0	2.8	2.0	11.6	18.6	32.3	31.7
574263	Subsoil	2.0	5.0	2.8	12.8	15.4	31.4	30.6

CHINO SILTY CLAY.

The surface soil of the Chino silty clay typically is a dark-gray, compact, sticky silty clay 12 to 15 inches or more in depth. The typical soil carries less mica than the lighter members of the series, but usually is of smooth texture because of its silt content. The organic-matter content apparently is high. Under favorable conditions of moisture the soil is fairly friable, but much of it puddles if cultivated when wet. The subsoil is variable in color and texture, like all the members of this series, and usually is distinct from the surface soil, but it generally consists of a silt loam, silty clay loam, or silty clay. It is mottled or grayish, contains calcareous concretions or marly material and usually extends to a depth of 6 feet or more.

This type is fairly uniform, though variations in color, texture, organic-matter content, and lime content occur. Some parts are rather light in texture, being low in silt and clay, and as mapped the type may include some undifferentiated areas of clay loam or silty clay loam. The color is more brownish or brownish gray along the margins of the type or where it adjoins soils of the Hanford or Yolo series, and is darker or black where it merges with Muck and Peat or darker colored types. The two bodies mapped several miles east of Paularino are distinctly brownish in color and very silty, but possess the mottled, calcareous subsoil typical of the Chino series. These bodies also differ in origin from much of the series. The content of organic matter in the more brownish soil apparently is lower than in the darker-colored areas or the small peaty areas which occur in some poorly drained situations. Concentrations of lime in the subsoil are most noticeable in the lower parts of the alluvial fan in the vicinity of the ocean, the better-drained areas usually containing calcareous material in the form of small concretions. Samples of the soil and subsoil collected 1½ miles west and one-half mile south of Wintersburg contained 7.72 per cent

and 8.56 per cent, respectively, of lime in the form of calcium carbonate. Others taken about 1 mile south of Gloryetta showed 15.79 per cent of calcium carbonate in the surface soil and 17.70 per cent in the subsoil. Marginal areas approaching the Hanford series are most micaceous. Where the type occurs as marginal bodies around old valley filling soils, it may consist of an overwash superimposed over the older material.

The Chino silty clay is an extensive type. It occurs in large bodies in the south-central and southwestern parts of the survey The more silty areas of the type lie largely south of Santa Ana, extending from Huntington Beach to Alamitos Bay, where they border areas of Tidal marsh.

The surface is very gently sloping to nearly flat, with some extensive shallow depressions. Much of the type is smooth and well adapted to irrigation. Poor subdrainage characterizes all the type, and a part of it has very poor surface drainage as well. The lower-lying areas are sometimes overflowed, the water remaining on the surface for long periods. Flowing wells are common over much of this type, and irrigation water is obtained from them and also by pumping. Drainage canals have been installed. Practically all the type is affected by alkali, which renders some parts useless for agriculture. The worst alkali areas are untilled and used for pasture. Alkali areas that can be cultivated are largely devoted to sugar beets, grain, and a few minor crops. The Chino silty clay includes some areas of reclaimed Tidal marsh.

Crop yields on this type depend largely upon the drainage and alkali conditions, the crops generally being more or less patchy.

Chino silty clay, heavy phase.—The surface soil of the Chino silty clay, heavy phase, consists of a dark brownish gray or dark-gray, sticky, compact silty clay, 12 inches or more in depth. The soil usually is puddled and of poor structure. The content of organic matter seems high. The soil sometimes contains mottled layers and iron stains, and is relatively free from mica as compared with the lighter-textured types of the series. The subsoil is a mottled or streaked brownish and grayish silty clay loam or silty clay extending to a depth of 6 feet or more. The subsoil from a few inches downward is water-logged, and the permanent water table is generally high. Concretions or seams of calcareous material are frequent in the subsoil.

The material of this phase is quite similar in general character to the typical Chino silty clay, but is of noticeably heavier texture, a sample of the surface soil collected 1 mile west and five-eighths mile north of the Springdale School indicating by mechanical analysis a clay content about 10 per cent higher than that of the typical Chino silty clay. The lime content of this sample was 2.45 per cent.

Some areas of this phase are rather uniform and fairly distinct, but others merge into adjacent types, as south of Santa Ana. A large part of the phase is of mixed origin, and represents material intermediate in character between that giving the recent alluvial soils and that forming the old valley filling types. Other parts are derived almost entirely from the same materials as the Yolo and Dublin soils. In parts of the phase the materials have been modified greatly by poor drainage.

The principal areas of the Chino silty clay, heavy phase, lie south of Santa Ana and east of Sunset Beach. A small area occurs southwest of Bolsa. The surface is nearly flat or gently sloping. Frequently the areas occupy the broad depressions that carry the drainage of higher lying types. Some areas are swampy during most of the year, and drainage is poor over all the phase. Seepage springs and flowing wells are common and the water table is high. Strong concentrations of alkali occur in most of the areas.

The Chino silty clay, heavy phase, is relatively unimportant, only a small part being used for crop production. Weeds and grasses common on alkali soils grow in uncultivated areas, which are used for pasture. Sugar beets and grain are the most important crops. The yields are variable, depending largely upon alkali and drainage conditions and fields usually have a spotted appearance. The average price of land of this type is lower than that of the other soils of the series.

The average results of mechanical analyses of samples of the soil and subsoil of the typical Chino silty clay, and the results of a similar analysis of a sample of the soil of the heavy phase are given in the following table:

Mechanical analyses of Chino silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical soil:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574211, 574264.	Soil.....	0.0	0.3	0.5	6.9	5.5	53.0	33.6
574212, 574265.	Subsoil.....	.1	.5	1.4	35.0	7.1	30.2	25.5
Heavy phase:								
574205.....	Soil.....	0.1	0.8	0.4	1.2	2.7	51.8	43.2

MUCK AND PEAT.

The surface soil of the Muck and Peat areas occurring in this survey is for the most part a black Muck, consisting mainly of organic matter but carrying small quantities of silt or other fine mineral sediments. Below a depth of 15 or 18 inches this black silty mass usually contains more distinct layers of mineral material of grayish color, alternating with layers of Peat, the entire mass gen-

erally extending to a depth of more than 6 feet. The material when dry is very light and will float on water.

The surface material is very friable and holds large quantities of water. The subsoil is often more porous, fibrous, and spongy, and generally contains undecayed roots of plants. It may contain some calcareous material, but as a whole it is practically free from alkali. Much of the Muck and Peat in this area is similar to its typical occurrence elsewhere in the Pacific coast region, but it includes some variations, owing to the fact that its areas are small and thus more easily modified by local influences. The greater part occupies small, usually elongated areas on flats affected by springs and seepage water, while parts of some areas lie at the foot of the bluffs of the old coastal plain deposits and receive seepage from higher areas. The depth and the relative quantity of the accumulated organic material present vary greatly, being shallower and containing more mineral matter where the areas merge with other soils. Some of the areas, such as those near Talbert, are covered with several inches of recently deposited mineral matter, similar to that composing the soils of the Hanford series.

Muck and Peat occurs only in the southwestern part of the survey. The two largest bodies lie southwest of Wintersburg and southeast of Paularino. Several other bodies are mapped near the Springdale School and a narrow area occurs near Talbert. Small bodies are encountered east and west of Smeltzer and east and north of Alamitos Bay.

Much of the Muck and Peat is similar in topography to the alluvial types with which it is associated. Some of the bodies occupy slight depressions, while others lie on slight ridges or hummocks and are distinct from the surrounding alluvial soils, above which they have gradually been elevated by the accumulation of decaying plants. The areas of Muck and Peat have a high water table, but are rarely overflowed. Most are tile drained and the water table is kept at a sufficient depth to permit the growing of shallow-rooted crops.

Owing to its small extent Muck and Peat is not of great importance. Practically all of it is cultivated, mainly to truck crops and sugar beets. It is considered well adapted to the truck crops, but growers say that the saccharine content of the beets is low, although the crop produces very good yields. The handling of this soil is difficult, as it is frequently unstable and will not support the weight of work stock. Owing to the great amount of water present it warms slowly, but crops do well without irrigation. Because of the diversity of crops in small plantings it is difficult to give an estimate of production, but yields usually are heavy.

Muck and Peat is usually sold in conjunction with other soils and the price depends largely upon that of adjoining land. The price frequently reaches $400 to $500 an acre.

TIDAL MARSH.

Tidal marsh in the Anaheim area consists of low-lying, undifferentiated soils, the greater part of which are subject to inundation by the tides. The material is brown, grayish brown, or gray and includes all textures from a sand to a clay. The soil has been deposited in protected inlets and bays. The material carried by the streams to these depressed, marshy areas, and distributed by stream and tidal currents usually is fine, and the greater part of the Tidal marsh is of heavy texture. The sandy parts usually are found about the openings of the bays or inlets where the waves and tides are most active or in places where beach sands have been blown inland.

Tidal marsh occurs along the coast from Newport Bay to Alamitos Bay as depressed bodies alternating with the prominent elevated segments occupied by old coastal plain deposits. One of the largest bodies occurs at Newport Bay, and extends up the bay for several miles. Other large bodies are mapped southeast and northwest of Huntington and Seal Beaches.

This soil occupies flat, low-lying areas, dissected by numerous tidal sloughs. The surface is periodically covered with salt or brackish waters. Some of the Tidal marsh is gradually being buried with fresh-water sediments, and there is usually an intermediate zone along the boundaries of recent alluvial soils that is not inundated by tides. The soil is water-logged, and requires drainage before it can be used.

Tidal Marsh in its present condition is typically nonagricultural. It supports a growth of salt-water plants. Its total area is diminishing, as parts are being reclaimed by the construction of levees and the installation of tide gates. Accumulations of salts usually are present in sufficient quantity to preclude the growing of cultivated crops, and washing of the soils with fresh water is necessary before they can be made productive.

Tidal marsh lies in proximity to the beach resorts, and some of it is being reclaimed and used for building sites. It has little or no value for agriculture until dyked and drained.

COASTAL BEACH AND DUNESAND.

Coastal beach and Dunesand comprises a variety of rather distinct but closely associated classes of topography, the soil materials of which are similar. The Coastal beach part occurs as a narrow shelving beach along the ocean front and in some instances flanks the

lagoons for short distances inland. The Dunesand part usually adjoins the beaches as a parallel zone of wind-blown material swept landward from them. The soil material in each case is a rather uniform light grayish-brown or brownish-gray, incoherent sand of medium texture more than 6 feet deep. The beaches and wave-formed sand barriers carry large quantities of marine shells, but the dune areas are relatively free from such material. Both classes of material are low in organic matter and of low water-holding capacity, and are almost entirely free from silty material.

As mapped in this survey, Coastal beach and Dunesand includes small areas of Madeland, the principal body of which occurs on Balboa Island in Newport Bay, where Coastal beach and Dunesand material has been dredged from the channels of the bay and deposited over the island, increasing the elevation sufficiently to guard against inundation by tides or flood waters from the streams entering Newport Bay. The greater part of the Madeland consists of sand, with a small quantity of heavier material. Marine shells are abundant throughout the mass, and the material has a light brownish-gray or grayish-brown color and a loose and incoherent structure.

These soils are nonagricultural.

RIVERWASH.

The Riverwash of the Anaheim area comprises the materials forming the beds of the immediate channels of the Santa Ana River and Santiago Creek. It is of finer average texture in this area than in the adjacent Pasadena and Riverside areas, consisting for the most part of sand of varying texture with local gravelly areas. It has a very low organic-matter content. The various materials of coarse texture usually are stratified, but small areas are often covered by thin layers or films of silt where the water velocity has been retarded. The Riverwash is coarsest and of least value where it occurs in the canyons and near their mouths, and finest in its lower extensions where the texture may be a fine sand or even a fine sandy loam. It is a nonagricultural soil.

ROUGH BROKEN AND STONY LAND.

Rough broken and stony land typically comprises areas the topography of which is too rough, broken, or precipitous, or in which outcropping rocks or bowlders are too frequent to permit of profitable cultivation under present conditions. It is considered nonagricultural, but contains numerous patches on ridge crests or more gentle slopes capable of tillage, such areas where of sufficient extent to warrant separation being mapped as types of the Altamont series. In the stony areas or those over which rock outcrop occurs the soil material usually is of residual origin, having been derived from the rocks

over which it lies. These rocks are largely sedimentary, although some igneous and metamorphic rocks are encountered, as east and southeast of El Modena. Rough broken and stony land occurs extensively in the northeastern part of the survey, where it includes most of the steep, broken ridges composing the part of the Puente Hills lying within the area. It includes the rougher parts of the hills south of La Habra, while other extensive bodies comprise the lower slopes of the Santa Ana Mountains, which extend into the survey from the east. The San Joaquin Hills in the southeastern part of the area contain some irregular areas. The high terraces defining Newport Bay north of Newport Beach are bordered by a narrow margin of Rough broken and stony land, and steep slopes occupying similar positions through the coastal plain region are included with this classification, although it is mainly associated with the residual soils.

The stonier areas or those marked by the presence of rock outcrop occur as extensive bodies in several parts of the survey. They are indicated on the soil map by rock outcrop symbols. Their most prominent occurrence is in an area several miles to the south of Irvine and west of the Laguna. This body has a steep, precipitous slope toward the east of several hundred feet, exposing thick strata of sedimentary rocks with considerable rock outcrop. Similar bodies are mapped near El Modena and at Red Hill, east of Tustin.

The soil material of Rough broken and stony land has a wide range in color, texture, and depth. The soil mantle usually is shallow, erosion is generally rapid, and the substrata often exposed. The water-holding capacity usually is low.

The typical parts of Rough broken and stony land, comprising the outcropping ledges, very steep faces, ravine sides, and choppy, severely eroded areas are unfavorable to tillage (Pl. III, fig. 1), but the mountain areas contain minor ridge crests and various other bodies which are favorable topograpically to tillage and are unused largely because of their inaccessibility. Some very steep slopes are tilled in this area, and it is probable that if irrigation water can be supplied patchy bodies of Rough broken and stony land may be utilized for intensive cropping.

Most of the Rough broken and stony land is covered with a brushy growth and held in large tracts for pasture. Some important oil fields are included in the northern part of the survey.

IRRIGATION.

Irrigation is generally necessary for the maximum production of crops in this area, although several important crops are grown without it. Irrigation by canals began about 1835 when water was

diverted from the Santa Ana River for use on the lands adjacent to and west of the Santa Ana Canyon. In 1873 ditches were extended from the Santa Ana for the irrigation of lands to the south and east of the river, and later irrigation from Santiago Creek was developed. The earlier attempts at irrigation were confined largely to the northeastern and eastern parts of the survey in the vicinity of streams. Later the lower lying lands toward the ocean were irrigated from flowing wells, which constitute an important source at the present time. Irrigation with water pumped from nonflowing wells has also been extensively developed.

According to the census of 1910, 2,215 farms, or about 70 per cent of the total number, were irrigated in Orange County. The irrigated area totaled about 55,066 acres, of which 28,263 acres were supplied with water from streams by gravity and 110 acres by pumping from the same source. About 6,526 acres were watered from flowing wells and 20,157 acres were supplied with irrigation water pumped from wells, so that about one-half the acreage irrigated in 1910 in Orange County was supplied from wells. Much of the included part of Los Angeles County in the western and northern parts of the survey is also irrigated—to some extent by gravity canals, but more largely from wells. While no figures are available showing the exact acreages irrigated in this section, the practice is very similar to that carried on in Orange County.

The watersheds lying within the Anaheim area are minor factors in the supply of irrigation water, most of the smaller creeks carrying water only during parts of the wet season. The supply conveyed by gravity canals is taken from the Santa Ana River and Santiago Creek in the northeastern and eastern parts of the survey and to a small extent from the San Gabriel River in the western part. Measurements of the Santa Ana River at Rincon, about 5 miles from where the river enters this area, between 1898 and 1906 show a mean discharge of 118 cubic feet per second.[1] There were 588 flowing and 580 pumped wells with a combined capacity of 353,636 gallons per minute reported in Orange County in 1910. These wells are chiefly located in the central and western parts of the area, and have a constant supply of water. The southwestern part of the area includes an artesian belt which is subject to contraction and expansion in succeeding dry and wet seasons. In 1912 it was estimated by the State Conservation Commission of California that the ground water underlying parts of the area averaged 20 feet lower than average levels of 15 years previously.

In 1910 there were 619 separate irrigation enterprises in Orange County, with a total of 309 main ditches, totaling 180 miles in

[1] U. S. Geol. Survey, Water Supply Paper No. 300.

length. Five main systems furnish water for much of the orchard district of Orange County. The water of the Santa Ana River is distributed principally by two systems. One covers about 8,100 acres on the north and west sides of the river, largely in the vicinities of Anaheim, Fullerton, and Placentia, the supply being augmented by pumping from wells between Fullerton and Placentia. The second extensive system taking water out of the Santa Ana River diverts its supply by the same weir as the first system mentioned, with a canal which follows the river channel around the hills at Olive. From this system the water is distributed to regions about Orange, Santa Ana, and Tustin. The supply of this system also is augmented by pumping from wells and irrigates a total of 17,200 acres. A third project, covering 627 acres, also receives water from the Santa Ana River. The water of Santiago Creek is distributed by two systems, one on each side of the stream. The one on the north irrigates 1,050 acres near Villa Park, while the other supplies 750 acres in the vicinity of El Modena. The main ditches of some of the principal systems are concrete lined over much of their courses, and the systems using Santiago Creek waters maintain a submerged dam, which is one of the few that intercept all underflow.[1]

The remaining large number of systems are small pumping plants or systems that utilize the flow of artesian wells. Excess flood waters of the Santa Ana and San Gabriel Rivers and Santiago Creek frequently are used for the irrigation of low-lying lands along their courses.

The average cost per acre for the installation of irrigation systems in Orange County, according to the 1910 census, is about $28 or $30, while operation and maintenance average about $2.70 per acre per year.

The alluvial soils and to a less extent the old valley-filling soils are irrigated, while the residual soils are largely unirrigated. The use of water in the area varies widely and depends on a number of factors, such as character of the soil, kinds of crop or degree of development, and seasonal conditions. More water is applied to citrus than to deciduous orchards, and soils of lighter texture require greater or more frequent applications than those of heavier texture. Practically all the orchard crops are irrigated, but many of the field crops, such as beans sugar beets, and grain, are grown by dry-farming methods or with only moderate applications of water.

DRAINAGE AND ALKALI.

The residual soils, alluvial soils, and those derived from the older valley-filling material, lying in the northern, eastern, and southeastern parts of the survey usually are well drained and normally free

[1] Report of the Conservation Commission of California, 1912.

from alkali. As the ocean is approached a region of poorer drainage, accompanied by alkali accumulation, is encountered in the alluvial areas. The general region lying between the ocean and a line running southeastward from near Norwalk is subject to poorer drainage than the remainder of the area, although boundaries between the poorly drained and well-drained sections are not distinct. The broad poorly drained region contains many slight ridges and, along the coast, upland terraces which are better drained than usual. The poor drainage is due in part to a high-water table and also to the occasional overflows from the main stream at times of exceptional flood.

Much of this region originally was nonagricultural because of its marshy condition, but drainage systems have been installed and the water table kept low enough to permit tillage. This work was accomplished largely through the organization of drainage districts. The drainage of the lowlands is accomplished mainly by means of open ditches supplemented by minor laterals, while local tracts are tile drained, as in areas of Muck and Peat and the Chino soils, (Plate III, fig. 2.) The region is still occasionally overflowed, but under present conditions it is largely maintained in a condition favorable for agriculture.

The alkali lands practically coincide with the poorly drained area affected by a high-water table. Most of the alkali land has an elevation of less than 100 feet. The areas begin as narrow tongues occupying gentle swales and gradually broaden toward the ocean, opening out into the flattened, poorly drained region along the coast. Most of the alkali lands lie in a large area extending northwestward from the lower course of the Santa Ana River. This region is broken by bodies of more elevated soils that are free from alkali, but is in the main sufficiently affected to influence crop production. Another important body of alkali land lies southeast of the Santa Ana River. In addition to these two main areas there are some areas of alkali land on the upper alluvial fans, which usually lie in depressed positions and receive seepage from higher lying soils. Practically all the alkali lands are of recent alluvial character. The old valley-filling soils are nearly always free from alkali, but small parts even at considerable elevation, contain appreciable quantities. In such cases most of the alkali occurs several feet below the surface, and may represent accumulations formed under former more poorly drained conditions.

The soluble salts composing the alkali vary in different parts of the area. In general, however, the region is one of "white alkali," the "black alkali," or sodium carbonate, being a minor constituent and prominent only in restricted local areas. Sodium sulphate seems

to predominate in the higher alkali areas removed from the ocean and sodium chloride in the low-lying bodies along the coast. Other salts are present in varying quantities, but these two form by far the greater part of the total. The alkali present in the soil and its distribution from the surface downward are subject to variation within short distances. An endeavor was made in this survey to divide the alkali lands into two classes, indicated on the soil map by the symbols A for high average and S for low average concentrations, based on the quantity of salts present in the soil. The class embracing land of low average concentration is composed largely of soils having an average of less than 0.2 per cent of alkali in the surface 6 feet, the class comprising land of high average concentration largely having more than this amount. There are, however, important exceptions to this classification. The first group contains broad areas which contain very slight quantities largely in the surface few inches, the alkali not being very prominent under any condition. It also contains areas which are extremely spotted or which have in local spots concentrations of 1 per cent or more. The second group contains extensive bodies that contain, to a depth of 6 feet, an average of 0.6 per cent, with streaked and spotted areas of smaller percentages. Some of the worst affected areas are those lying south of Dyer and northwest of Irvine and in the low flat country along the coast.

Most of the lands affected by alkali are of medium or light texture and in such soils maximum concentrations usually are found in the surface few inches, unless the surface soil is underlain by heavy-textured materials, in which case the subsoil may be badly affected. Some of the Tidal marsh material has been covered by a thin overwash of alluvial silty material, retaining its original salt content, and now constitutes a heavily impregnated subsoil. The heavier textured soils usually exhibit fewer surface indications of alkali than the light-textured soils bearing similar concentrations. Some of the low-lying alkali lands have been encroached upon by recently deposited surface material, and in such places the subsoils bear considerable alkali, which is not indicated by surface conditions.

The use of the alkali lands of the area depends largely on the percentage of alkali present, the texture of the soil, and local water supply. Only a small part remains untilled, and this usually consists of heavy-textured low-lying and very poorly drained soils, such as Tidal marsh or adjoining areas of other types.

Sugar beets are by far the most extensive crop on the alkali soils of the area. They are grown on various soils ranging in alkali content from very slight to very high and uniform percentages. Yields of this crop vary widely. In some instances it is grown where only a very patchy stand can be obtained.

Some beans are grown in the areas bearing the smallest quantities of alkali, but in general the affected areas shown on the map are poorly adapted to this crop. Alfalfa is an important crop where the water table is lower than the average and alkali concentrations are moderate or low, but difficulty is often had in obtaining and maintaining a stand. Grain and grain hay are crops often grown in rotation with sugar beets. Certain other crops, such as some of the truck or garden crops, are grown, the yields varying widely and often being uncertain.

The deep-rooted orchard crops are not grown under average alkali conditions, as much because of adverse drainage conditions as the presence of alkali, and in some instances climatic conditions in the lowland areas also are unfavorable. Untilled parts of the alkali areas are used for pasture, and the prevailing moist conditions are favorable for a heavy production of salt grass and other forage. There is a rather consistent tendency to extend cultivation on the alkali lands. Considerable effort has been made to improve the poorly drained and alkali lands and increase their productiveness. In most instances reclamation and improvement are being carried on as a part of the ordinary use of the land, such as the tillage and irrigation that accompanies the growth of many crops. Some of the soils are easily improved, this being particularly true of the light textured types. Lowering of the water table and cultivation to reduce evaporation do much toward reducing the rapidity of salt concentration, while irrigation water, the natural rainfall, and in some instances overflow waters assist in leaching away the alkali.

SUMMARY.

The soil survey of the Anaheim area covers the most important agricultural part of Orange County, California, with smaller parts of adjoining counties. The area lies southwest of Los Angeles and fronts on the Pacific Ocean. It is bounded on the north and east by hilly sections that are largely too rough and broken for agricultural use. It is joined on the north by the Pasadena area and on the west by the Los Angeles area, which are covered by other soil surveys.

The Anaheim area embraces three physiographic divisions—the inclosing broken hills on the north and east, remnants of somewhat elevated old valley surfaces or marine terraces, which lie along the base of the hills or border the ocean front and, as the most extensive division, broad, rather smooth and gently sloping alluvial fans.

Elevations range from sea level in some coastal sections to a maximum of 1,600 feet in the hill portions. A large part of the area lies below 100 feet and most of it below 200 feet in elevation.

The Santa Ana River crosses the main part of the area, and the San Gabriel River crosses the western section. These streams directly drain only a small part of the area, owing to their built-up position, which makes the entrance of lateral streams difficult. Santiago Creek drains a part of the survey and flows into the Santa Ana River, but the greater part of the run-off from the surrounding hills and main valley slopes is carried largely by minor independent streams.

The area is thickly populated, and agriculture is by far the most important industry. According to the census reports the area in 1910 had a population of something less than 40,000, but the population has greatly increased in recent years. About 60 per cent of the population reside in the cities or towns, less than one-half living under strictly rural conditions. Santa Ana, with a population of 8,429 in 1910, is the largest city. There are a number of other cities and towns in the area ranging from several hundred to about 3,000 inhabitants.

Transportation facilities are good.

The area is well supplied with schools, telephones, and other modern conveniences.

The climate is very pleasant and favorable to the production of a wide range of agricultural products. The average annual rainfall ranges from 10 to 15 inches in different parts of the survey, while the mean annual temperature averages about 64° F. Danger from frost influences the distribution of citrus and other fruits, the higher lands being least susceptible to damage. A growing season of about 10 months is available for sensitive crops, while the hardy crops can be grown throughout the year.

The rainfall is confined to the winter months, and this has an important bearing on agricultural practices and renders irrigation necessary for many fruits and field crops which make their greatest growth during the summer season.

The agriculture of the area is highly developed. Most of the products are highly specialized and are grown for export rather than for local consumption. Chief among the products are oranges, lemons, and walnuts, with some deciduous fruits. Beans are an important field crop, and large quantities of sugar beets are utilized by local factories. Grain and grain hay cover large acreages. Subsidiary crops and industries, such as truck crops, dairying, and poultry raising, are locally important. The region is one of high average land prices.

The soils of the Anaheim area fall mainly in three general groups—residual soils, old valley filling or coastal plain soils, and recent alluvial soils.

The first group includes those soils derived in place by the weathering and disintegration of consolidated rocks, and usually occupies rolling or mountainous areas. Tillable areas are used largely for grain and hay production. The residual soils are inextensive. They are classed with the Altamont and the Diablo series.

The soils derived from old valley filling or coastal plain deposits are relatively extensive. They are grouped in the Ramona, Montezuma, and Antioch series. These series are intermediate in elevation between the recent alluvial soils and the residual soils. The Montezuma and Antioch soils are not important agriculturally. They are irrigated to only a small extent, being used principally for dry-farm crops, mainly beans and grain. The Ramona soils are irrigated in many places, and large plantings of citrus fruits have been made. Most of the orchards are still young.

The recent-alluvial soils are the most important, both in extent and agricultural use. These soils are in places subject to overflow or accumulation of alkali, but, on the whole, are very valuable farming types, having a smooth surface, a deep, friable soil, and subsoil conditions favoring deep-rooted crops. The facilities for irrigation are good. These soils are grouped in the Hanford, Yolo, Dublin, and Chino series.

Several groups of miscellaneous material also are mapped, one of which, Muck and Peat, consisting of cumulose deposits, is productive when drained. The other miscellaneous types, Tidal marsh, Coastal beach and Dunesand, Riverwash, and Rough broken and stony land are practically all nonagricultural.

Irrigation is an important factor in the agriculture of the area, as most of the fruits and many other crops require it. In 1910 there were 2,215 irrigated farms, or about 70 per cent of the total number in Orange County. The recent alluvial soils are most extensively irrigated, although important parts of the old valley filling and coastal plain soils also are watered.

Parts of this survey are affected by a high water table and consequent injurious accumulations of alkali. Most of the alkali land is tilled and used mainly for the production of sugar beets. Considerable effort has been made to reclaim the alkali lands and make them more productive.

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[PUBLIC RESOLUTION.—No. 9.]

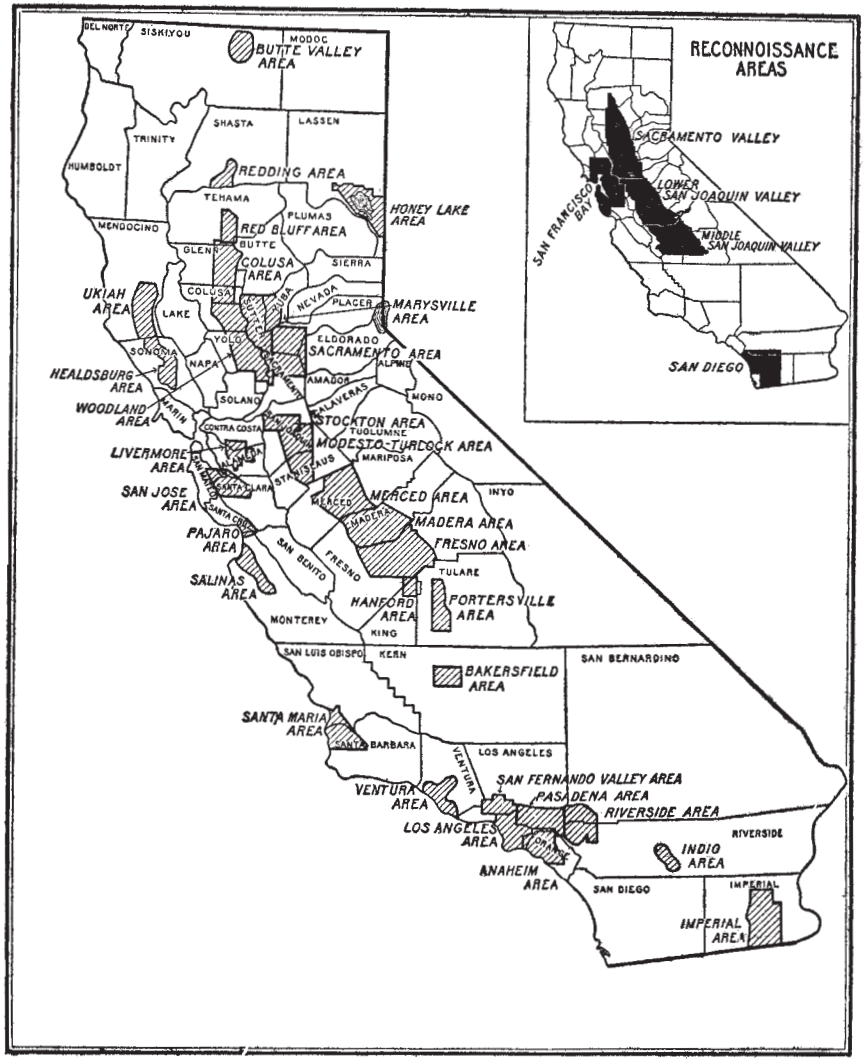
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]



Areas surveyed in California

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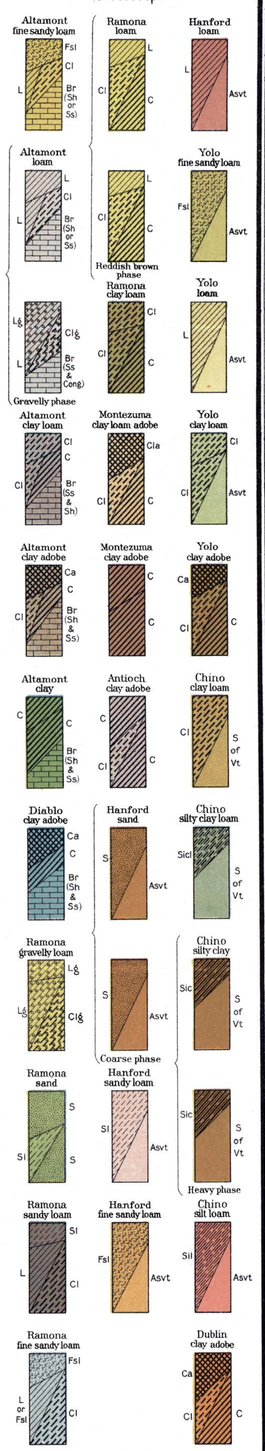
U.S. DEPT OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
CALIFORNIA
ANAHEIM SHEET

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
THOMAS F. HUNT, DIRECTOR,
CHARLES F. SHAW, IN CHARGE SOIL SURVEY.

SOIL PROFILE
(6 feet deep)



LEGEND

Fsl	Fine sandy loam
L	Loam
Cl	Clay loam
Br	Bedrock
Sh	Shale
Ss	Sandstone
C	Clay
Ca	Clay adobe
S	Sand
Sl	Sandy loam
Cla	Clay loam adobe
Asvt	Alluvial strata (various textures)
S of Vt	Strata of various textures
Sic	Silty clay
Sicl	Silty clay loam
Cong	Conglomerate
L&	Loam with gravel
Cl&	Clay loam (gravelly)

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort.
Secondary roads and Trails
Railroads Steam and Electric
Bridges, Ferry
R.R. crossings, Tunnel
Ford, Dam
School or Church Cemeteries
Mine or Quarry Mine dumps Made land
Bluff, Escarpment, Rock outcrop and Triangulation station
Stony and Gravelly areas
Soil boundaries
Boundary lines
Boundary lines
Boundary lines
U.S. township and section lines

RELIEF
(Printed in brown or black)

Contours Depression contours
Prominent Hills Mountain Peaks
Sand, Wash, and Sand dunes
Shore and Low-water line, Sandbar

DRAINAGE
(Printed in blue)

Streams
Lakes, Ponds, Intermittent lakes
Intermittent Streams
Springs, Canals and Ditches, Flumes
Swamp Salt marshes
Submerged marsh Tidal flats

The above signs are in current use on the soil maps Variations from this usage appear in some maps of earlier date.

LEGEND

Altamont fine sandy loam — Af
Hanford sandy loam — Hs
Altamont loam — Al
Hanford fine sandy loam — Hf
Gravelly phase — Al
Hanford loam — Hl
Altamont clay loam — A
Yolo fine sandy loam — Yf
Altamont clay adobe — Ao
Yolo loam — Y
Altamont clay — Ac
Yolo clay loam — Yc
Diablo clay adobe — Dy
Yolo clay adobe — Yo
Ramona gravelly loam — Ro
Chino clay loam — Cc
Ramona sand — Ra
Chino silty clay loam — Cs
Ramona sandy loam — Rs
Chino silty clay — Cy
Ramona fine sandy loam — Rf
Heavy phase — Cy
Ramona loam — Ro
Chino silt loam — Cl
Reddish-brown phase — Ro
Muck and Peat — Mp
Ramona clay loam — Rc
Tidal marsh — Tl
Montezuma clay loam adobe — Mc
Coastal beach and Dunesand — Co
Montezuma clay adobe — M
Riverwash — Rv
Antioch clay adobe — Aa
Rough broken and Stony land — R
Hanford sand — Hs
Dublin clay adobe — Dc
Coarse phase — Hs
High average concentrations of Alkali — A
Low average concentrations of Alkali — S
Free from Alkali — F

NOTE:
Contours are published as shown on the Geological Survey sheets without adjustment to changes in drainage.

Macy H. Lapham, Inspector Western Division.
Soils surveyed by E.C. Eckmann, in charge, A.T. Strahorn, and L.C. Holmes of the U.S. Department of Agriculture, and J.E. Guernsey, of the University of California.

BASE MAP IN PART FROM
U.S. GEOLOGICAL SURVEY SHEETS

Scale 62500
Miles
Kilometers
Contour interval 25 and 100 feet.
Datum is mean sea level.

SNYDER & BLACK, N.Y.

Field Operations
Bureau of Soils
1916